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Contributions to the Study of Chesapeake Bay Striped Bass

COORDINATED BY
JAMES E. SYKES

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THE CHESAPEAKE BAY COOPERATIVE STRIPED BASS PROGRAM[1]

JAMES E. SYKES

ABSTRACT

The long-range objectives of coordinated research on the fishery, designed to assess the effects of fishing, are to estimate abundance, mortality rates, and exploitation parts of the striped bass, *Roccus saxatilis*, in Chesapeake Bay. The first phase, involving the cooperation of biologists of Maryland, Virginia, and the U. S. Bureau of Commercial Fisheries, was a pilot program of systematic tagging and recovery in 1957–8. The nature of further research on striped bass populations in Chesapeake Bay is described.

Introduction

During the 5-year period 1953 through 1957 the average annual commercial catch of striped bass, *Roccus saxatilis*, on the Atlantic coast was approximately 5,000,000 pounds and was valued at $1,000,000. The area of highest abundance was Chesapeake Bay where an average of 3,000,000 pounds was landed annually having a dockside value of $700,000. The pounds of fish caught in the bay by the sport fishery is not known, but observation has shown it tc be among the larger of sport catches on the Atlantic coast.

Although the fishery is economically and recreationally important, many of the requisites for successful management are not yet known. Biological research on striped bass in Chesapeake Bay since the 1930's

[1] Contribution No. 173, Maryland Department of Research and Education, Solomons, Maryland.

dealt largely with age, growth, feeding habits, migration, and the location of spawning and nursery areas. Most of the programs were relatively small in scope and localized in area. In recent years the States of Maryland and Virginia recognized the need for population studies as a necessary aid in the management of their striped bass fishery. Estimates of abundance and mortality rates and the identification of separately exploitable components of the fishery were desired. The U. S. Bureau of Commercial Fisheries was requested by these states to lend support in a comprehensive striped bass research program.

A coordinated study was begun in 1957 to assess the effects of fishing upon Chesapeake Bay striped bass. The Virginia Fisheries Laboratory, the Maryland Department of Research and Education, the Maryland Department of Tidewater Fisheries, and the United States Bureau of Commercial Fisheries were research cooperators. The first phase of the study was a pilot program of systematic tagging and recovery in 1957 and 1958. It was designed for 1) determination of the seasonal location of striped bass by age classes; 2) development of a satisfactory tag and a tagging technique which would serve the purposes of the investigation; 3) location of sources of adequate tag recoveries from both sport and commercial fisheries to reflect quantitatively in subsequent studies the population or subpopulations available to the respective fisheries; and 4) evaluation, in addition to earlier meristic and tagging studies, of criteria fo. separating subpopulations in the bay.

Field data, collected cooperatively and in most events simultaneously, were pooled and members of the cooperating laboratories volunteered to analyze and report on phases of the research program. Results of the pilot tagging studies are given in the following sections of this report.

Lewis describes the methods employed in selecting the most satisfactory tag for the Chesapeake Bay program. Mansueti, and Massmann and Pacheco in two separate reports, interpret age, size, growth, sex, and migration of striped bass in relation to the fisheries of both Maryland and Virginia.

Since this portion of the study was completed, research dealing specifically with the population dynamics of the Potomac River striped bass has continued. This tributary supports the largest striped bass fishery in the area. Research is planned for the other major tributaries and the bay proper for determination of abundance, mortality rates, the existence of subpopulations, the contribution of stocks to other areas, and scientific methods of utilization.

All agencies involved have contributed as equitably as possible in their responsibilities of finance and manpower. The cooperation of state and federal personnel in this program has been outstanding and illustrates the results which can be obtained through the joint effort of laboratories having limited resources for conducting a large investigation.

Atlantic Coast Striped Bass Program, U. S. Bureau of Commercial Fisheries, Beaufort, North Carolina.

Comparison of Three Tags on Striped Bass in the Chesapeake Bay Area[1]

ROBERT M. LEWIS

ABSTRACT

Petersen disk, nylon streamer, and jaw ring tags were applied to striped bass, *Roccus saxatilis*, in the Chesapeake Bay area in 1957. The primary objective was to determine the tag most suitable for a study of movement and in estimating population size. Tag return data were analyzed statistically to test comparative merits of tags. Petersen disk tags were returned selectively from gillnets in some size classes of fish as compared to nylon streamer and jaw ring tags. There was little difference in the suitability of jaw ring and streamer tags to requirements of the study. The streamer tag was chosen only because it was easier to obtain than the jaw ring tag.

Prior to beginning the tagging study of striped bass, *Roccus saxatilis* (Walbaum), in Chesapeake Bay, it was recognized that estimates of abundance, mortality, and movement would be largely dependent upon the adequacy of the tag employed. One of the principal objectives of tagging during the first year of study was the selection of a tag that was durable and would neither tangle in gear nor hamper the activity of fish.

The practicability of using a variety of tag types on striped bass has been investigated by others. Davis (1959:319–29) reported on tests of Petersen, streamer, and spaghetti tags on striped bass in North Carolina. His results indicated that streamer tags were most suitable for studies of populations and fish movement in that area. Vladykov (1957:345–9) first described tests with the jaw ring (split ring and plate) tag. Calhoun (1953:209–18) reported that the Petersen disk tag placed under the first dorsal fin seemed the most satisfactory in aquarium tests of four tags in four body locations. A review of these findings indicated that at least one of the above tag types would probably satisfy requirements on striped bass research in Chesapeake Bay but did not resolve the choice among cooperating investigators. For this reason Petersen, nylon streamer, and jaw ring tags were tested so that one could be selected which would most nearly meet all requirements of the study.

Tests of tag types were made possible by the cooperation of the following individuals: William H. Massmann and Anthony L. Pacheco[2], Virginia Fisheries Laboratory; Edgar H. Hollis, Maryland Department of Tidewater Fisheries; and Romeo J. Mansueti, Maryland Department of Research and Education. These individuals and their colleagues were responsible for a large portion of the field work and resulting tag-return data analyzed in this paper.

Materials and Methods

Petersen disk, nylon streamer, and jaw ring tags were applied to striped bass caught by haul seine, pound net, drift and stake gillnets, otter trawl, and hook and line. Fish were weighed, measured to fork length (F.L.), tagged, and released in the area of capture. When applying two or more types of tags for testing purposes, an attempt was made to use them in equal numbers for each 1-inch increment of fish length. Scale samples were taken for age and growth determination.

Tags:—The Petersen tag consisted of two red plastic disks $\frac{7}{16}$-inch in diameter. One disk was blank and the other bore a code

[1] Contribution No. 174, Maryland Department of Research and Education, Solomons, Maryland.

[2] Presently with the U. S. Bureau of Commercial Fisheries.

number on one side, with the return address and $1.00 reward notice on the other side. The tag was attached by inserting a stainless steel pin through the back of the fish under the first dorsal fin.

The streamer tag consisted of a numbered Petersen disk attached to the fish with a 7-inch loop of nylon net-twine. The loop was threaded through the back of the fish under the second dorsal fin with a 7-inch upholsterer's needle having a notched eye. The tag was then tied so that the disk trailed over the caudal peduncle.

The jaw ring tag consisted of a Petersen disk attached to either a ¾-inch or 1-inch diameter stainless steel ring which was clamped around the mandible with pliers. The size of the fish determined the diameter of the ring.

Tagging:—Petersen disk and nylon streamer tags were tested by biologists of Virginia Fisheries Laboratory and the U. S. Bureau of Commercial Fisheries. During 11 engagements, 1,422 striped bass were tagged and released in the James, York, and Rappahannock Rivers during February, March, and April 1957 (Table 1). Of these, 98 percent were taken from haul seines and 1 percent each from stake gillnets and an otter trawl. Fifty-three percent of the haul seine fish were tagged with Petersen disk tags and 47 percent with nylon streamer tags. In the Rappahannock and James Rivers, equal numbers of fish were tagged with Petersen and streamer tags. An effort was made to apply equal numbers of the two types of tags each trip in the York River, but this was not always possible.

TABLE 1.—Numbers of Petersen and streamer tags applied to striped bass, *Roccus saxatilis*, in the James, York, and Rappahannock Rivers, 1957, by Virginia Fisheries Laboratory, and number of returns by gear type.

Size classes (inches fork length)	Petersen tags			Streamer tags		
	Tags applied	Tag returns		Tags applied	Tag returns	
		Selective gear[1]	Nonselective gear[2]		Selective gear[1]	Nonselective gear[2]
7	1	—	—	3	—	—
8	12	2	2	19	—	—
9	65	5	5	75	—	1
10	144	23	24	124	5	19
11	116	21	16	95	2	12
12	94	28	11	106	4	8
13	52	22	4	57	3	5
14	52	14	1	47	3	2
15	61	17	5	51	6	1
16	39	12	—	37	2	3
17	21	8	1	12	6	1
18	20	8	—	8	2	—
19	6	3	—	2	—	—
20	71	17	11	32	1	5
Total	754	180	80	668	34	57

[1] Gillnet.
[2] Pound net, haul seine, fyke net, hook and line.

Biologists of the Maryland Department of Research and Education tested Petersen and streamer tags on striped bass from March through June 1957 in the upper Bay, the Potomac River, and the Chesapeake and Delaware Canal. During 22 engagements, 859 striped bass were tagged (Table 2). Eighty-four percent were from stake gillnets, 11 percent from drift gillnets, and 5 percent from hook and line.

Biologists of the Maryland Department of Tidewater Fisheries tested Petersen, streamer, and jaw ring tags on striped bass in the upper Bay and in the Chesapeake and Delaware Canal from February through November 1957. Two thousand forty-eight fish

TABLE 2.—Numbers of Petersen and streamer tags applied to striped bass, *Roccus saxatilis*, in the Potomac River, upper Chesapeake Bay, and Chesapeake and Delaware Canal, 1957, by Maryland Department of Research and Education, and number of returns by gear type.

Size classes (inches fork length)	Petersen tags			Streamer tags		
	Tags applied	Tag returns		Tags applied	Tag returns	
		Selective gear[1]	Nonselective gear[2]		Selective gear[1]	Nonselective gear[2]
≤9	8	5	1	3	—	—
10	35	15	4	32	2	2
11	74	45	8	77	15	1
12	79	33	5	78	25	10
13	63	36	3	63	21	7
14	67	26	3	59	16	5
15	44	16	4	42	9	3
16	40	17	3	37	9	1
17	19	9	2	18	8	2
≥18	11	3	2	10	2	1
Total	440	205	35	419	107	32

[1] Gillnet.
[2] Pound net, haul seine, fyke net, hook and line.

TABLE 3—Numbers of Petersen, streamer, and jaw ring tags applied to striped bass, *Roccus saxatilis*, in upper Chesapeake Bay and Chesapeake and Delaware Canal, 1957, by Maryland Department of Tidewater Fisheries, and number of returns by gear type.

Size classes (inches fork length)	Petersen tags			Streamer tags			Jaw ring tags		
	Tags applied	Tag returns		Tags applied	Tag returns		Tags applied	Tag returns	
		Selective gear[1]	Non-selective gear[2]		Selective gear[1]	Non-selective gear[2]		Selective gear[1]	Non-selective gear[2]
7	13	7	—	12	—	3	13	—	1
8	90	54	4	76	1	8	96	—	21
9	118	68	8	117	4	12	119	2	21
10	146	55	9	153	5	11	157	2	20
11	103	32	10	110	6	9	111	10	7
12	80	22	13	70	10	3	67	8	8
13	37	11	5	31	6	2	39	4	1
14	24	5	7	17	—	4	29	6	8
15	23	11	3	22	4	5	24	7	1
16	23	13	2	22	2	2	19	5	1
17	19	5	2	17	2	2	16	3	2
18	5	4	—	3	—	—	3	—	—
19	—	—	—	1	1	—	1	—	—
20	15	3	—	4	2	—	3	1	—
Total	696	290	63	655	43	61	697	48	91

[1] Gillnets.
[2] Pound net, haul seine, fyke net, hook and line.

were tagged during 27 engagements (Table 3). Sixty percent were from pound nets, 26 percent from haul seines, and 14 percent from drift gillnets.

Tag recovery:—Several methods were used to recover tags. Letters explaining the tagging program were sent to all licensed commercial fishermen, and biologists contacted the fishermen to collect tags. Letters and newspaper articles were employed in areas where sport and commercial fishermen were concentrated. When a tag was returned by mail with insufficient details regarding recapture, a card was sent to the fisherman requesting that the omitted items be completed.

Treatment of Tag Recovery Data:—Returns were classified by each cooperating agency as: (1) tags from selective gear (gillnet) which by mesh dimension determines the size range of fish captured; and (2) tags from non-selective gear (pound net, haul seine, fyke net, hook and line) which retains fish of all sizes. Of 1,384 recovered tags, 58 could not be classified by recovery gear or date of recapture and consequently were not used in analyses. Chi-square tests were employed in evaluating tag returns by gear, tag type, and size of fish. These tests were made separately for returns of tags applied by the three agencies.

Results

Analysis of Tag Returns

Results of chi-square tests based on returns from tags applied in the James, York, and Rappahannock Rivers by Virginia Fisheries Laboratory showed that: (1) in selective gear there was a significantly greater number of Petersen disk tags returned than nylon streamer tags among size classes of fish less than 17 inches F.L.; (2) in selective gear there was no significant difference between the number of returns of Petersen disk tags and nylon streamer tags for fish 17 inches or more in length (Table 4a); and (3) there was no significant difference in the number of Petersen disks and nylon streamer tags returned from non-selective gear for any of the size classifications (Table 4d).

Tag returns were compared from striped

TABLE 4.—Chi-square values in comparing returns of Petersen and streamer tags applied to striped bass, *Roccus saxatilis*, in the Chesapeake Bay area.

Laboratory and location of tagging	Size classes (inches-fork length)					
	≥12	≥13	≥14	≥15	≥16	≥17
Recaptured in selective gear						
a. Virginia Fisheries Laboratory (James, York, and Rappahannock Rivers)	62.73	38.33	21.84	14.57	9.86	2.99
b. Maryland Department of Research and Education (Potomac River, upper Bay, and Chesapeake and Delaware Canal)	12.76	11.55	5.76	3.83	1.69	0.004
c. Maryland Department of Tidewater Fisheries (upper Bay and Chesapeake and Delaware Canal)	17.58	13.86	13.91	11.31	7.15	0.44
Recaptured in non-selective gear						
d. Virginia Fisheries Laboratory (James, York, and Rappahannock Rivers)	0.09	0.04	0.003	0.004	0.72	0.21
e. Maryland Department of Research and Education (Potomac River, upper Bay and Chesapeake and Delaware Canal)	1.14	0.14	0.001	0.36	0.25	0.01
f. Maryland Department of Tidewater Fisheries (upper Bay and Chesapeake and Delaware Canal)	1.57	0.02	0.06	0.50	0.001	0.004

$\chi^2 = 3.84$ at the 5 percent level of significance.

bass tagged by the Maryland Department of Research and Education in the Potomac River, upper Bay, and Chesapeake and Delaware Canal. Tests between returns of Petersen and nylon streamer tags in selective gear produced the following results: (1) significantly greater numbers of Petersen tags were recovered from fish less than 15 inches F.L. than streamer tags; and (2) no significant difference was found between the number of recoveries of tags from fish equal to or greater than 15 inches F.L. (Table 4b). There was no significant difference between the number of recoveries from non-selective gear for any size group of fish (Table 4e).

Comparisons were made between returns of Petersen disk and nylon streamer tags on fish tagged in the upper Bay and the Chesapeake and Delaware Canal by the Maryland Department of Tidewater Fisheries. The following results occurred for returns in selective gear: (1) significantly greater numbers of Petersen tags were recovered from fish less than 17 inches F.L. than streamer tags; and (2) no significant difference occurred between the number of recoveries from fish equal to or greater than 17 inches F.L. (Table 4c). There was no significant difference between the number of recoveries in non-selective gear for any size group of fish (Table 4f).

Comparisons were also made between Petersen disk and jaw ring tags and between jaw ring and streamer tags from the returns of tags applied to fish in the upper Bay and Chesapeake and Delaware Canal (Table 5). When comparing returns of Petersen disks with those of jaw ring tags from selective gear, the following results occurred: (1) significantly greater numbers of Petersen tags were recovered from fish less than 16 inches F.L. than were jaw ring tags; and (2) there was no significant difference between the

TABLE 5.—Chi-square values in comparing returns of tags applied to striped bass, *Roccus saxatilis*, in the upper Chesapeake Bay region by Maryland Department of Tidewater Fisheries.

Tag types	Size classes (inches-fork length)					
	≥12	≥13	≥14	≥15	≥16	≥17
Recaptured in selective gear						
Petersen versus jaw ring	13.28	8.35	4.32	4.62	3.25	0.74
Streamer versus jaw ring	0.28	0.73	2.60	0.98	0.28	0.02
Recaptured in non-selective gear						
Petersen versus jaw ring	1.03	0.46	0.03	0.04	0.07	0.00
Streamer versus jaw ring	0.01	0.34	0.07	1.17	1.02	0.19

$\chi^2 = 3.84$ at the 5 percent level of significance.

number of recoveries of tags from fish equal to or greater than 16 inches F.L. There was no significant difference between the number of recoveries from these two tag types from non-selective gear for any size groups of fish. When comparing jaw ring tag returns to those of streamer tags, there was no significant difference in selective or non-selective gear between the number of returns for any of the size classes of fish tested.

A variation in the point of significance by size classes of fish occurred in those tagged by the Maryland Department of Research and Education and the other two agencies when comparing Petersen and streamer tags in selective gear. In these fish (Table 4b) the difference in return of the two tags was non-significant among size classes equal to and greater than 15 inches, and in those tagged by the other two agencies the difference was non-significant among size classes equal to and greater than 17 inches (Tables 4a, b). The difference was non-significant in fish equal to or greater than 16 inches in comparing Petersen and jaw ring tabs in selective gear (Table 5). It is not definitely known why the point of separation was different in the above instances; however, a variation in mesh size by area of recapture is probably responsible.

TABLE 6.—Numbers of Petersen, streamer, and jaw ring tags applied to striped bass, *Roccus saxatilis*, concurrently by the Maryland Department of Tidewater Fisheries and number of returns by tag type and by time interval [Percentage of recoveries in parentheses].

Tag Type	Number applied during spring	Days free						
		0–7	8–28	29–49	50–70	71–91	92–450	≥451
Petersen	308	19 (6.2)	9 (2.9)	17 (5.5)	5 (1.6)	12 (3.9)	54 (17.5)	— (—)
Streamer	293	9 (3.1)	4 (1.4)	9 (3.1)	4 (1.4)	6 (2.0)	12 (4.1)	— (—)
Jaw ring	306	11 (3.6)	5 (1.6)	5 (1.6)	4 (1.3)	3 (1.0)	17 (5.6)	1 (0.3)
	Number applied during fall							
Petersen	376	3 (0.8)	28 (7.4)	10 (2.6)	21 (5.6)	55 (14.6)	114 (30.3)	5 (1.3)
Streamer	342	4 (1.2)	12 (3.5)	1 (0.3)	3 (0.9)	2 (0.6)	46 (13.4)	5 (1.4)
Jaw ring	455	7 (1.5)	23 (5.0)	1 (0.2)	2 (0.4)	4 (0.9)	65 (14.2)	13 (2.8)

CONDITION AND DURABILITY OF RECOVERED TAGS

The majority of tags were returned within a few months after being released and were clean and legible. In the spring of 1959, a marine growth was observed on a few streamer tags which were attached more than one year prior to recapture. Infected tagging wounds were rare except in the small number of fish bearing tags on which a growth occurred.

Identical plastic was used in the manufacture of all three types of tags, but the jaw ring tags which were out more than a year had a tendency to become cracked and worn. The Petersen and streamer tags did not exhibit this characteristic. It appears that the method of attachment may have resulted in different conditions occurring in the tags. The Petersen tag was held firmly to the sides of the fish and the streamer tag trailed over the caudal peduncle. The jaw ring tag was attached to the side of the jaw and gave the plastic disk more opportunity to rotate, wear, and be lost from the ring.

An accurate comparison of tag types recovered by time interval could be made only when the three types were used simultaneously in one fishing season. For instance, fish tagged with streamer tags in February could not be compared with those tagged with jaw rings in May because the former would be subjected to the spring fishery immediately, whereas the latter tagged at the end of spring fishing would not be subject to recapture until at least the following fall. The length of time between tagging and recapture of the jaw ring tag in this instance would appear to be much greater than that of the Petersen tag. The Maryland Department of Tidewater Fisheries was the only cooperator applying enough rings concurrently with the other two types to make this comparison possible. The data from that agency were available from both spring and fall tagging in 1957 and were used in comparing length

of time free by tag type (Table 6). The percentage of return for the Petersen tag was higher than for the other two tags except in two instances, (0–7 and ≥451 day intervals) in the fall tagging. Examination of streamer and jaw ring tag returns by the chi-square method showed no significant difference between tag-recapture interval by tag type.

Conclusions

Statistical comparison of Petersen, streamer, and jaw ring tag returns showed that Petersen tag returns were significantly greater in selective gear than streamer and jaw ring tags. There was no significant difference in non-selective gear in the return of the three tag types. A tag which was non-selective in fishing gear was desired for Chesapeake Bay striped bass research. Tests proved that both streamer and jaw ring tags would fulfill requirements even though some plastic disks were reported to become separated from the stainless steel ring in the jaw tags. It was necessary that a choice be made between the two types. Streamer tags were chosen for use in subsequent portions of the program because import duty on jaw rings made them expensive and more difficult to acquire.

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Atlantic Coast Striped Bass Program, U. S. Bureau of Commercial Fisheries, Beaufort, North Carolina.

Age, Growth, and Movements of the Striped Bass, *Roccus saxatilis*, Taken in Size Selective Fishing Gear in Maryland[1]

ROMEO J. MANSUETI

ABSTRACT

Scale samples and tag returns were studied from over 1100 striped bass caught in 1957–58 at six locations in the Chesapeake Bay region of Maryland. Most fish, represented by age groups II–IV, were taken in size-selective gillnets and some by hook and line, otter trawls, and haul seines. Known males ranged as follows: age groups—II–XI, fork lengths—13–37 inches; and, weights—0.7–25 pounds. Females combined with fish of unknown sex ranged as follows: age groups—I–XIV, lengths—6–42″ F.L.; and, weights—0.8–49 pounds. Both sexes grew at the same rate during the first three years of life. Beginning with age group IV, the males grew at a consistently lower rate than the females and unknown sex group. Growth calculated from gillnetted fish was slightly higher than normal during the first two years of life, after which there was no apparent difference between selectively and non-selectively caught fish.

Tagging results show that the bulk of the 418 (38 percent) recaptured striped bass remained in the Maryland part of Chesapeake Bay. Three tagged fish were recaptured outside the bay on the Atlantic coast, and two were taken in the Virginia part of the bay. The restricted recaptures around the tagging sites, in spite of time free, suggested that during the first several years of life the movements of local populations are minimal. Data is presented to show that larger striped bass moved greater distances on the average than smaller fish. Some tag returns showed that spawning fish returned to the same spawning site one and two years later. Exchange between bay and river populations of Maryland striped bass was not very great. New results have strengthened the previous assumption that the Potomac River population may be relatively self-contained, at least during the first three or four years of life.

Introduction

The object of this paper is to contribute knowledge of the age, growth and movements of striped bass, *Roccus saxatilis* (Walbaum), by summarizing observations collected in the Chesapeake Bay part of Maryland during the large-scale tagging program in 1957 and early 1958. An important aspect of this study is the emphasis on vital statistics of the species caught largely by size-selective gillnets. It also represents observations on growth before the new minimum legal size was raised from 11 to 12 inches total length in Maryland. This project was part of a cooperative undertaking between the Maryland Department of Research and Education, Maryland Department of Tidewater Fisheries, Virginia Fisheries Laboratory, and the U. S. Bureau of Commercial Fisheries. The long-range objective of this work is to shed light on the utilization, migrations, biology, and best methods of study of the striped bass in Chesapeake Bay.

Information derived from age, growth, and tagging studies are useful in striped bass management for these general reasons: (a) year classes and their relative strength can be identified and monitored; (b) the relationships between age, size, and time of recruitment into the anglers' creels and commercial fishermen's nets (12-inch total length minimum legal size since June, 1957) can be ascertained; (c) the rate and nature of migration of different age groups, sizes

[1] Contribution No. 175, Maryland Department of Research and Education, Solomons, Maryland.

and sexes can be determined; and, (d) forecasting of the relative abundance of year classes can be placed on a sounder footing. Angling pressure has increased markedly in recent years and commercial exploitation for the species has been maintained at a high level in Chesapeake Bay. At the same time, stocks, while fluctuating greatly in relative abundance, have generally been high and have contributed to important commercial harvests in spite of extensive utilization. This is apparently due to the appearance of several strong year classes of striped bass (Murphy, 1960:74; and Hollis, 1960:22).

Although much attention has been devoted to the striped bass, there are many aspects of the biology of Chesapeake Bay populations that must be extended. The following studies contain the bulk of information on the striped bass. Raney (1952:56–60) has summarized most of the general work on age and growth, while Pearson (1938:839), Tiller (1943:14; and 1950:28), Vladykov and Wallace (1952:150–9), and Mansueti (1955:2; and 1956:3) dealt specifically with Chesapeake Bay samples. Raney (1952:19–30) also synthesized the state of knowledge about the migrations and local movements of striped bass throughout its range, while Pearson (1933:15–7; and 1938:842–4), Vladykov and Wallace (1938:67–86; and 1952:163–75), Mansueti (1956:4–6; and 1958:22), Hollis and Davis (1955:2), and Chapoton and Sykes (1961:18–9) have provided pertinent data on striped bass movements in Chesapeake Bay.

This paper summarizes only part of the data derived from striped bass studies during 1957 and 1958; the same fish used in this study have provided the basis for a part of the detailed comparison study of three types of tags summarized by Lewis (1961). Sykes (1958B:376) mentioned certain aspects of the cooperative study. A preliminary summary dealing with striped bass movements resulting from this study was given by Mansueti (1958:22).

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Methods and Materials

General Comments:—A total of 1103 striped bass were tagged, from which lengths, weights, sex data and scale samples were obtained. Table 1 contains a frequency distribution of these fish by tagging locality, tag type and the method of fishing or gear type. Since the bulk of the sample was derived from gillnets, noted for their high selectivity for specific sizes of fishes, mesh sizes were recorded for almost all specimens. Two major mesh-size groups were utilized by the gillnet fisheries: 3–4 inch stretch mesh (S.M.) and 4–5 inch S.M.

Sex Identification:—The sexually mature individuals were identified wherever possible during winter and spring. As Raney (1952:31) and Sykes (1958A:104) indicated, sexing of live striped bass, other than ripe males, is extremely difficult. Virtually all mature males in spring and some during winter were easily identified when milt exuded in their spawning or running-ripe condition. One small male, which was 7 inches in fork length (F.L.) just before the formation of a second annular ring in late spring, for example, was found to exude milt. Vladykov and Wallace (1952:162) reported ripe males at similar small sizes. Females were positively identified by gentle manual expression of ripe ova or accidental extrusion of unripe eggs. All other fish not

identified as ripe males were assumed to be immature females, although such was not truly the case as shown below. Of the group classified as "females and unknown sex," 18 individuals were positively identified as ripe females, while 10 individuals were tentatively identified as "green" or unripe females on the basis of greatly enlarged abdomens and deep profile of the anterior trunk. As a check on this technique fish between 10 and 22″ F.L. were procured periodically in March and April, 1957 from commercial nets, sexed externally, and finally dissected for positive identification. A total of 60 fish were examined. Before internal examination, 18 were sexed as spawning males, all verified upon dissection, while the balance were unknown. Dissection revealed four additional males with enlarged but apparently resting or prespawning testes. The remainder consisted of 32 immature females, while six between 18 and 22″ F.L. were sexually mature females with unripe ova. Thus, the category of the "females and unknown sex" was contaminated with some males, but this had no appreciable effect on the growth data.

Length, Weight and Scale Samples:—Standard (S.L.), fork (F.L.), and total lengths (T.L.) were taken from a large proportion of the fish tagged so that conversion factors would be available for comparison with other studies. Six two-inch groups, each with about 25 fish, were studied for differences in F.L.–T.L. and T.L.–F.L. conversion factors with respect to size. There was actually little difference between the groups. Thus, to convert F.L. to T.L. it was found that the factor 1.07 could be used, and to convert T.L. to F.L. use the factor 0.93. The factors for S.L.–T.L. and T.L.–S.L. were 1.08 and 0.92, respectively. About a dozen scales were removed from the left side of the body of each fish above the lateral line between the two dorsal fins. This location corresponded to that used by Scofield (1931:26), Merriman (1941:23), Tiller (1950:9), and Robinson (1960:279). Key scales were not used. At least four scales from each fish were mounted and impressed on a 1 x 3 x 0.030 inch cellulose acetate slide. Since samples of two-year old fish were very large, these were reduced somewhat by about 15 percent by a random sub-sample. Coupled with a very small number of scales that were regenerated or broken, these subsamples reduced the age and growth sample to 744 fishes.

Aging Procedure:—A Rayoscope and a Bausch and Lomb microprojector with a magnification of 25 times (×) were used to age and measure the scales. Fish were aged by counting the annular rings, according to the assumptions of Scofield (1931:26), Merriman (1941:23–5), and other authors summarized by Raney (1952:57–8). Age groups as used in this paper refer to fishes with a specific number of rings if taken after annulus formation in spring and summer. Thus a two-ring fish is from age group II. Fish taken in winter when growth had ceased or early spring before annulus formation, however, are advanced one year; thus, a two-ring fish during this period was classified as age-group III (see Rounsefell and Everhart, 1953:309). Some large females were found to possess accessory rings, tentatively assumed to be spawning marks because of their close proximity to annuli during the fourth, fifth, and sixth summers of life. These were not counted as annuli, in line with Scofield (1931:29–30). The locations of the focus, annuli, and the scale margin were marked on a paper strip along the radius, diagonally from the focus to the right shoulder. Measurements to the nearest millimeter or tenth of an inch were used to determine the body–scale length relationships and in back-calculating growth with the aid of nomographs. All measurements were finally converted to inches in the final report. All scales were aged independently by at least two and in many cases three experienced fish scale readers. Whenever disagreements resulted, especially among the older fish, these were re-read. Those upon which no agreements could be made were rejected from growth calculations. The danger of the latter procedure, in which the older, slower growing specimens may be discarded, is recognized. Rejections were low, so that their effects on growth estimates were minimal.

Body length–scale length regression was determined by stratifying the samples into one-inch class intervals and utilizing, where

available, 10 randomly selected fish from each group for a total of 160 fish. The fish were grouped by scale length and an average body length was computed. The length-weight relationship was determined by grouping the fish by one-half inch fork length intervals and computing the mean fork length and weight of the fish in each interval. These averages were then converted into logarithms and calculated values were plotted on log-log paper.

Tags:—Three types of tags were used: (a) Petersen red plastic disks, attached by means of a nickel pin inserted directly through the back of the fish; (b) nylon streamer with a trailing plastic disk, threaded through the back and securely knotted (Davis, 1959:319) and (c) metal split ring with a Petersen disk attached to the lower jaw by special pliers first described and used by Vladykov (1950:121). The fish were selected in such a manner that all size groups were marked in about equal numbers. Split ring tags were not available until late in spring of 1957, so that fewer of these were attached than other types (Table 1). A reward of $1.00 per numbered tag was sent to the fishermen returning them. Tag returns were facilitated by newspaper publicity but they cannot be considered maximal since no extensive effort was made to canvass fishermen in the field for tags during this experiment.

Results and Discussion

Age and Growth Studies

Body length–scale length relationship:—Fig. 1 shows the result of plotting the mean fork length in each scale measurement group against the mean scale length and fitting the data with a regression line by the least squares method. The regression line is described by the formula: $Y = 0.43 + 3.74\,X$, where Y is the fork length in inches, X is the enlarged scale radius, and 0.43 is the fork length intercept in inches. Scofield (1931:39) and Merriman (1941:32) determined values of about 0.4 inches and 0.25 inches respectively, while Robinson (1960: 281) found it to be 0.97 inches. Since the smallest fish used in the body–scale relationship was 5.5 inches F.L., the extrapolation of the regression line through the fork length axis is an artificial value, and probably does not represent the body length at the time of scale formation as is concluded in many similar studies (as in Scofield, 1931:39). Thus, Mansueti (1958B:19–23) indicated that scales are first evident at about 0.75 inches, or at a size about 40 percent greater than the Y intercept value given above. Nevertheless, all back-calculations were corrected for the fork length intercept. An error in the estimation of the intercept can produce the effect of Lee's Phenomenon in the age groups I–IV which are based on large samples (Tables 2–3). It is possible that estimates of length at past annuli will decrease slightly as the length of the fish at capture increases, as a result of the intercept. The growth of the sample of males and the mixture of females and fish of unknown sex were calculated with the aid of a direct proportion nomograph without a correction factor and compared with the growth of the sample after the back calculations had been corrected. The former was consistently higher than the latter during the first few years of life, but the difference was small.

Age and growth:—The fork length at the end of each year of life was calculated for each fish, and these lengths were averaged to obtain a mean length at the end of each year of life for the age groups of males and for the mixture of females and fish of unknown sex (Tables 2 and 3). The means for each year of life were then averaged by sexes to get the weighted grand average calculated fork length. The average annual increments of growth were then determined for each year of life. Fig. 2 and Table 5 shows that males and the females mixed with fish of unknown sex grow at about the same rate for the first three years of life. After age group IV, females grow at a significantly greater rate and a consistent difference is maintained between the sexes, as has been shown for the striped bass by Scofield (1931: 32–3, 35) and Robinson (1960:281). This data on differential growth suggests that the "females and unknown sex" category primarily consisted of immature and prespawning females. Tables 4 and 5 which show

this difference between the sexes also strengthen the assumption.

Most of the growth estimates from older fish are based on very small samples so that little reliance can be placed on the calculated differences at advanced ages. Of interest was the discovery in the Elk River of a very large and sexually mature male in its twelfth year that weighed 24.5 pounds and measured 37.2 inches F.L. Scofield (1931:35) pointed out that males older than 10 years in California waters were quite rare, while the largest male striped bass on record (Vladykov and Wallace, 1952:155, 162) weighed 16.5 pounds and was about 31.5 inches total length (T.L.). The largest male examined by Scruggs (1957:154) was 30 inches long T.L. and in its seventh year. Pearson (1938:830) recorded a male 30.7 inches T.L. but did not give its age or weight. Large females, ranging from 25 to almost 50 pounds were observed, but these are known to be common for this species (Raney, 1952:63–4). Such fish ranged between 10 and 14 years old (Fig. 4). Chapoton and Sykes (1961:15–6) indicated that fish about 50 pounds in weight may be 18 years old.

The greatest annual growth for both sexes, 6.4 inches for males and 6.6 for the females and unknown sex occurred in the second year of life (Fig. 2). These data were higher than 3.4 inches for males and 3.6 for females (Scofield, 1931:38) and 5.7 for the two sexes (Robinson, 1960:285–6) both of which were also highest in the second year. Merriman (1941:70) presented data somewhat less consistent with these results. The comparatively more rapid growth for striped bass caught by the gillnets is consistent with the expectation that such selective gear take a comparatively large segment of the faster-growing and larger than average individuals from the age group II population. Table 2 and 3 also show that when different year classes are compared at corresponding periods of life, no consistent decrease in calculated lengths with increasing age (i.e., Lee's Phenomenon, defined by Hile (1936:222) as the "apparent decrease in the calculated growth as it is determined from successively older groups of individuals") is observed, in spite of the comments made in the body-scale discussion above. The validity of back calculating growth was confirmed by comparing the measured lengths at capture and calculated lengths for fish of the same age groups (Table 4).

A further confirmation of age analysis and average growth attained at the end of each year of life for these Maryland striped bass was obtained by comparing growth estimates with those published for other studies (Table 5). Estimates of growth for Maryland striped bass during the first two years of life were somewhat higher than those for all other studies except that recorded by Fitzpatrick and Cookson (1958: 10), Scruggs (1957:154), and Stevens (1957: 154). Their samples were taken by methods selective for the larger sizes. Fitzpatrick and Cookson's age-length relationships differed considerably from those cited in Table 5, especially among the oldest fish. These differences may reflect age assignment errors of one or more years in the Massachusetts' striped bass. Similarities between growth after the third year of life are close for most of the other studies cited, although some differences in all of them could be caused by sample size, fishing mode selectivity, and errors in aging among the older fish. It is possible, nevertheless, that the high estimates of growth of the Maryland striped bass during the first two years of life are due to gillnet selectivity of the faster growing fish at young ages, but that subsequent estimates are close to normal.

Length - weight relationship:—The length-weight relationship, augmented with approximate age designations for the two sexes, is useful for predictive purposes, given one of the variables. Fig. 3 shows that although the slope is identical there is a slight but consistent difference in the location of the fitted line for each sex; i.e., males of a given length weigh less than females of the same length. The relationship for Maryland striped bass is similar to length-weight data given by Clark (1938: 177), Merriman (1941:6), Morgan and Gerlach (1950:24), Vladykov (1953:73) and Robinson (1960:283). Fig. 3 also suggests that the annual weight increments of

TABLE 1.—Summary of striped bass, *Roccus saxatilis*, marked with various types of tags during 1957 and early 1958 in Chesapeake Bay, Maryland.

Fork Length in Inch Intervals	Location and Dates of Tagging																							
	Chesapeake Bay, Aberdeen and Worton Pt. nr. Head (March 6-15, '57)				Potomac River, nr. U. S. Route 301 Bridge (March 14-15, '57)				Elk River and Chesapeake & Delaware Canal (April 26-May 1, '57)				Chesapeake Bay at Patuxent River[2] (June 14-24, '57) and Choptank River (April 25, '57).[3]				Chesapeake Bay, Various Mid-Channel Stations from Potomac R. to Worton Pt. (January 8-9, '58)				Total all areas			
	Tag Type[1]																							
	P	N	R	T	P	N	R	T	P	N	R	T	P	N	R	T	P	N	R	T	P	N	R	T
5–6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	10	—	10	—	10
6–7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18	—	18	—	18	—	18
7–8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	34	—	34	—	34	—	34
8–9	1	—	—	1	—	—	—	—	1	—	—	1	1	4[2]	1	6[2]	—	20	—	20	3	24	1	28
9–10	3	2	—	5	—	—	—	—	1	—	—	1	1	4[2]	2	7[2]	—	28	—	28	5	34	2	41
10–11	30	30	—	60	1	1	—	2	—	—	—	—	4	8[2]	2	14[2]	—	35	—	35	35	74	2	111
11–12	66	68	—	134	1	—	—	1	1	1	1	3	6	9[2]	6	21[2]	—	18	—	18	74	96	7	177
12–13	66	67	—	133	7	6	—	13	1	1	—	2	5	7[2]	3	15[2]	—	5	—	5	79	86	3	168
13–14	45	43	—	88	14	17	—	31	2	2	1	5	2	1	1	4	—	6	—	6	63	69	2	134
14–15	29	22	—	51	36	34	—	70	2	3	4	9	—	—	—	—	—	1	—	1	67	60	4	131
15–16	8	5	—	13	31	31	—	62	4	6	4	14	1[3]	—	—	1[3]	—	1	—	1	44	43	4	91
16–17	5	1	—	6	28	27	—	55	7	9	8	24	—	—	—	—	—	—	—	—	40	37	8	85
17–18	1	1	—	2	12	13	—	25	5	4	3	12	1[3]	—	—	1[3]	—	—	—	—	19	18	3	40
18–19	1	—	—	1	3	3	—	6	1	—	1	2	—	—	—	—	—	—	—	—	5	3	1	9
19–20	—	—	—	—	—	—	—	—	1	1	—	2	—	—	—	—	—	—	—	—	1	1	—	2
20–21	—	—	—	—	1	—	—	1	1	—	—	1	—	—	—	—	—	—	—	—	2	—	—	2
21–22	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	1	—	—	1
22–23	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	1	—	1
23–24	—	—	—	—	1	1	—	2	1	—	1	2	—	—	—	—	—	—	—	—	2	1	1	4
24–25	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	1	1
25–26	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

26–27	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
27–28	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	1	1
28–29	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	1	1
29–30	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	1	1
30–31	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	1	1
31–32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32–33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
33–34	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	1	—	1
34–35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
35–36	—	—	—	—	—	—	—	—	—	—	—	—	—	—	[1]	[1]	—	—	—	—	—	—	1	1
36–37	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
37–38	—	—	—	—	—	—	—	—	—	1	—	1	—	—	[1]	[1]	—	—	—	—	—	1	1	2
38–39	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	1	1
39–40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	[1]	[1]	—	—	—	—	—	—	1	1
40–41	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
41–42	—	—	—	—	—	—	—	—	—	1	1	2	—	—	—	—	—	—	—	—	—	1	1	2
42–43	—	—	—	—	—	—	—	—	—	1	2	3	—	—	—	—	—	—	—	—	—	1	2	3
Mean Length	12.6	12.4	—	12.5	15.4	15.3	—	15.4	16.1	18.8	21.2	18.8	11.5	10.9	11.2	11.2	—	9.2	—	9.2	13.6	11.4	19.2	13.2
Standard Error of Mean	0.10	0.09	—	0.06	0.15	0.15	—	0.13	0.60	1.40	1.61	0.78	0.29	0.24	0.34	0.67	—	0.16	—	0.16	0.11	0.15	1.39	0.04
Size Range	8.5–18.5	9.5–17.5	—	8.5–18.5	10.5–23.5	10.5–23.5	—	10.5–23.5	8.5–23.5	11.5–42.5	11.5–42.5	8.5–42.5	8.5–17.5	8.5–13.5	8.5–39.5	8.5–39.5	—	5.5–15.5	—	5.5–15.5	8.5–23.5	5.5–42.5	8.5–42.5	5.5–42.5
Number of Fish	255	239	—	494	135	133	—	268	29	32	32	93	19	33	15	[4]72	—	176	—	176	440	613	50	1103
Type of Gear	Stake Gillnet				Stake Gillnet				Drift Gillnet				Hook and Line[2, 3]				Semi-balloon Trawl				—			

[1] Tag types: P—Petersen disk; N—Nylon streamer; R—stainless steel jaw ring; and T—total.
[2] Includes 18 striped bass tagged in the mid-Patuxent River on May 10, 1958 from a haul seine.
[3] Includes 5 striped bass tagged in the Choptank River on April 25, 1957 from a drift gillnet. They are not included in the estimate of the mean size.
[4] The mean value is based on 67 specimens.

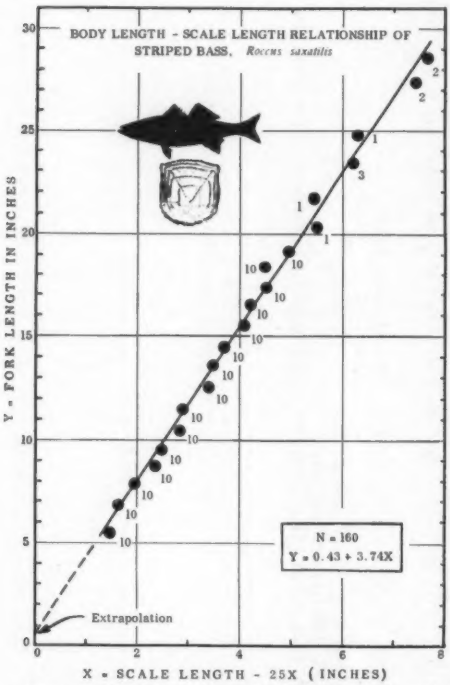
BODY LENGTH - SCALE LENGTH RELATIONSHIP OF STRIPED BASS, Roccus saxatilis
Y = FORK LENGTH IN INCHES
X = SCALE LENGTH - 25X (INCHES)
N = 160
Y = 0.43 + 3.74X
Extrapolation

Fig. 1.—Body length—scale length relationship of striped bass, *Roccus saxatilis*, tagged during 1957 and early 1958 in Chesapeake Bay, Maryland.

males and the females mixed with fish of unknown sex are most rapid during the second, third and less so, the fourth, years of life, and between 11 and 20 inches. Afterwards, they fluctuate greatly in weight addition, although there is a general leveling off. Fig. 4 provides a simple graphic summary of the relationship between age, length and weight.

Effects of gear selection on growth:—Gillnets have long been known to be selective for certain sizes of fish within a very narrow length range. They also apparently select the larger or faster-growing individuals from the youngest age groups that are available (Scofield, 1931:74; and Jones, 1960:177). It should be stated at this point that none of the striped bass over 8 pounds in weight were truly gilled; virtually all large fish were snagged by mouth parts, spines, gill covers, or by Petersen disks. In spite of higher estimates of growth among the first two years of life, overall growth estimates from these selectively-caught fish do not differ greatly from estimates from non-selective gear. These results, however, should be investigated further by a specially designed study. Growth estimates from a combined sample, for example, can be af-

TABLE 2.—Calculated lengths of male striped bass, *Roccus saxatilis*, tagged in 1957 in Chesapeake Bay, Maryland.

Age Group	Year Class	Number of Fish	Fork Length at Capture	Calculated Fork Length in Inches at End of Year[1]										
				1	2	3	4	5	6	7	8	9	10	11
I	1956	—	—	—	—	—	—	—	—	—	—	—	—	—
II	1955	128	13.9	6.1	12.8	—	—	—	—	—	—	—	—	—
III	1954	79	15.7	4.3	10.4	15.4	—	—	—	—	—	—	—	—
IV	1953	12	17.3	5.1	8.6	12.8	16.8	—	—	—	—	—	—	—
V	1952	1	18.0	4.0	7.0	9.6	14.0	17.5	—	—	—	—	—	—
VI	1951	2	22.1	4.8	8.6	12.6	15.5	18.6	21.7	—	—	—	—	—
VII	1950	0	—	—	—	—	—	—	—	—	—	—	—	—
VIII	1949	1	29.3	6.1	10.7	13.6	16.4	20.9	24.5	26.9	28.9	—	—	—
IX	1948	0	—	—	—	—	—	—	—	—	—	—	—	—
X	1947	0	—	—	—	—	—	—	—	—	—	—	—	—
XI	1946	1	37.2	6.5	9.6	13.6	17.6	22.7	23.8	28.7	30.8	32.8	34.5	35.7
Grand Average	—	—	—	5.3	11.7	15.0	16.6	19.7	23.4	27.7	29.7	32.7	34.5	35.7
Standard Error of the Mean	—	—	—	0.22	0.27	0.35	0.86	0.96	1.15	0.10	—	—	—	—
Average Annual Growth Increment	—	—	—	5.3	6.4	3.3	1.6	3.1	3.7	4.3	2.0	3.0	1.8	1.2
Number of Fish		224	—	224	224	89	17	5	4	2	1	1	1	1

[1] Corrected with the Y intercept value in the body length-scale length relationship formula Y = 0.43 + 3.74 X.

TABLE 3.—Calculated lengths in inches of striped bass, *Roccus saxatilis*, consisting of a mixture of females and fishes of unknown sex[2] tagged in 1957 in Chesapeake Bay, Maryland.

Age Group	Year Class	Number of Fish	Fork Length at Capture	Calculated Fork Length in Inches at End of Year[1]													
				1	2	3	4	5	6	7	8	9	10	11	12	13	14
I	1956	3	6.4	6.0	—	—	—	—	—	—	—	—	—	—	—	—	—
II	1955	372	12.5	5.1	11.7	—	—	—	—	—	—	—	—	—	—	—	—
III	1954	115	15.8	4.0	9.7	15.3	—	—	—	—	—	—	—	—	—	—	—
IV	1953	12	16.6	4.3	8.3	12.2	16.1	—	—	—	—	—	—	—	—	—	—
V	1952	4	24.0	4.8	10.4	15.6	19.1	22.7	—	—	—	—	—	—	—	—	—
VI	1951	3	25.5	5.5	11.5	16.5	19.1	22.5	24.1	—	—	—	—	—	—	—	—
VII	1950	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
VIII	1949	1	29.0	6.7	10.0	13.2	18.1	20.0	23.6	25.4	26.8	—	—	—	—	—	—
IX	1948	1	31.0	6.0	12.6	16.4	18.3	19.8	23.2	27.1	29.2	30.2	—	—	—	—	—
X	1947	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
XI	1946	3	34.8	5.6	10.3	15.8	18.6	21.2	23.4	25.6	28.1	30.3	32.0	33.9	—	—	—
XII	1945	3	42.2	8.0	12.9	18.0	23.1	26.7	29.9	32.6	35.1	37.0	38.3	39.6	40.8	—	—
XIII	1944	2	39.5	8.1	12.8	17.4	21.1	23.4	25.9	28.0	30.7	33.0	34.7	36.2	37.2	38.5	—
XIV	1943	1	41.8	6.5	11.4	17.6	19.8	22.8	26.2	29.2	31.2	34.0	36.4	37.8	39.6	39.7	41.1
Grand Average	—	—	—	4.9	11.5	15.3	18.4	21.9	25.4	28.5	30.8	33.7	35.4	36.8	39.6	38.7	41.1
Standard Error of the Mean	—	—	—	0.12	0.16	0.29	0.99	1.18	1.60	2.09	2.04	1.99	2.14	1.86	1.67	2.00	—
Average Annual Growth Increment	—	—	—	4.9	6.6	3.8	3.1	3.5	3.5	3.1	2.3	2.9	1.7	1.4	2.8	−0.9	2.4
Number of Fish	—	520	—	520	517	146	30	18	14	11	11	10	9	9	6	3	1

[1] Corrected with the Y intercept value in the body length-scale length relationship formula $Y = 0.43 + 3.74\ X$.
[2] See text for explanation.

fected by sample size of fish taken from the different mesh sizes of gillnet. Fig. 5A shows that the length frequency distribution of three age groups of striped bass are not identical for the two sizes of gillnet mesh, 3–4″ S.M. and 4–5″ S.M. The mode for 3–4″ S.M. is about 12 inches F.L. and for 4–5″ S.M. is about 14 inches for age group II. The difference in the modes of the catches from age group III is less: 3.4″ S.M. is about 15.5 inches and 4–5″ S.M. is about 16 inches F.L. The data are too fragmentary for modal estimates for age group IV. Fig. 5B shows that the mode for the combined data is approximately 14 inches, which means that gillnets with 3–5″ S.M. range principally harvest the age groups II and III.

Table 6 shows the calculated growth of males and females mixed with fishes of unknown sex from the two mesh size groups and illustrates two points: (a) the largest striped bass were taken by the larger mesh; and (b) estimates of length for the larger fish were generally smaller during the first and second year of life than the fish taken by the smaller mesh. The data suggests compensatory growth in the smaller fish, a phenomenon documented for fish by Van Oosten (1929:370–3), Hile (1936:282), and as has been recorded by Tiller (1943:14) for striped bass. This growth, however, takes place one and two years later than the second year of life. It is contrary to the generalization made by Jones (1960:178) that some fish are naturally faster growers than other individuals of a given species and that, other things being equal, they remain so for their whole lives, as he observed in the haddock of the North Sea. Although comparative data on growth of striped bass during 1957 from non-selective nets is not available, it is concluded that growth based on samples from selective gear during the first two years and perhaps third year of life do not precisely represent average sizes attained. As Table 5 shows, however, the differences are small when they are compared to the results of other studies in many parts of the striped bass's range.

MOVEMENTS

General nature of recaptures:—Results of tagging and releasing 1103 striped bass during 1957 and early 1958 with the subsequent recapture of 38 percent indicated that the bulk of recaptured fish remained in the Maryland part of Chesapeake Bay

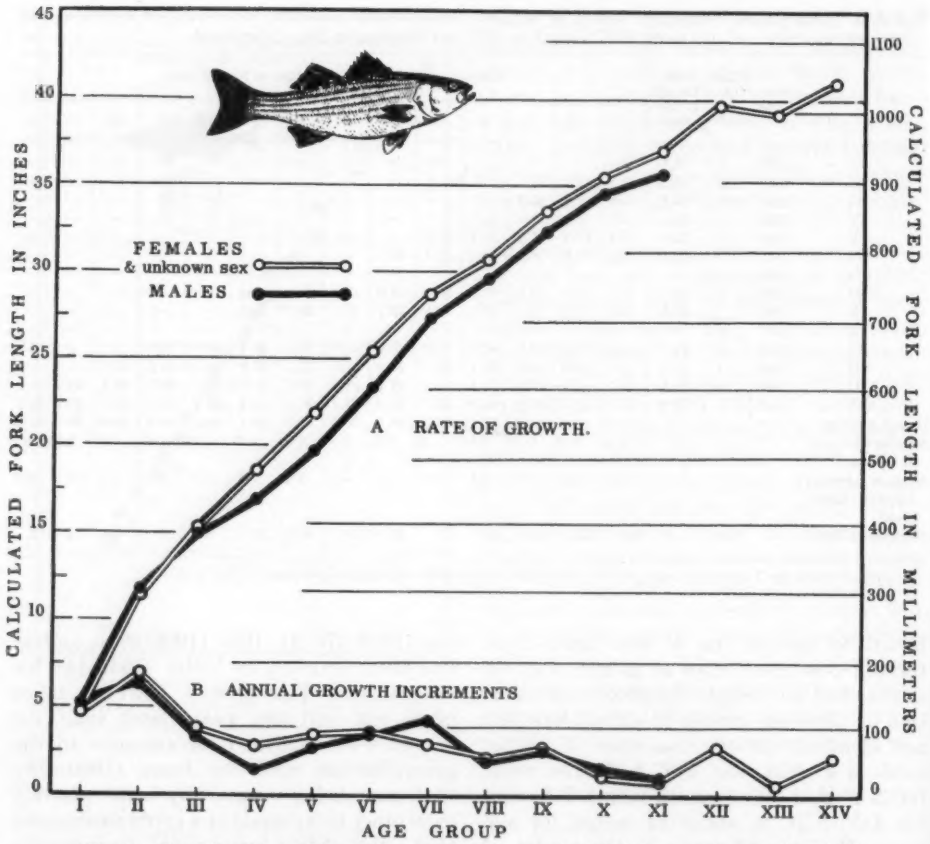
CALCULATED FORK LENGTH IN INCHES
CALCULATED FORK LENGTH IN MILLIMETERS
FEMALES
& unknown sex
MALES
A RATE OF GROWTH.
B ANNUAL GROWTH INCREMENTS
AGE GROUP
I II III IV V VI VII VIII IX X XI XII XIII XIV
0 5 10 15 20 25 30 35 40 45
0 100 200 300 400 500 600 700 800 900 1000 1100

Fig. 2.—Growth of striped bass, *Roccus saxatilis*, as calculated from scale samples of fish caught in 1957 in Chesapeake Bay, Maryland.

for a two years period. Although tagged at widely separated localities in Chesapeake Bay and tributaries of Maryland (Fig. 7–11), recaptures were generally clustered around the tagging site; however, distances of dispersal of individuals varied greatly. Fig. 6 shows the length frequency distributions at tagging of the tagged and released sample with the recaptured fish. It suggests that the recaptured fishes were a representative sample of the marked fish.

The progressive dispersal of tagged fish as reflected by recaptures in relation to time free (just over two years) is shown in Figures 7–11 for each tagging site. The time intervals conform in general to multiples of weeks and months with respect to the different seasons. Most of the recaptures were taken in the general vicinity of the release site, in spite of the time free. A small number traveled relatively greater distances within the Bay; the maximum was 151 miles. Although a little over one-half of the tagged fish were recaptured within a month of their release, 46 percent were at liberty more than four weeks and perhaps had ample opportunity to make extensive movements. One of the last recaptures received, for example, was taken from a pan-sized fish (between 12–15″ long) that had been free 603 days, and yet was recaptured only about 12 miles from the marking site; i.e., from off Aberdeen Proving Grounds to Swan Point Bar in upper Chesapeake Bay. No

TABLE 4.—Comparison between measured fork lengths in inches and weight in ounces with calculated lengths and weights of striped bass, *Roccus saxatilis*, tagged in 1957.

Age Group	Males						Females and unknown sex[1]					
	Mean Lgth. at Capture	Mean Calculated Lgth.	Mean Wgt. at Capture	Mean Calculated Wgt.	Number of Fish		Mean Lgth. at Capture	Mean Calculated Lgth.	Mean Wgt. at Capture	Mean Calculated Wgt.	Number of Fish	
					Measured	Calculated					Measured	Calculated
I	—	5.3	—	—	—	224	6.4	4.9	—	—	—	520
II	13.9	11.7	18.2	10.8	135	224	12.5	11.5	16.4	13.0	154	517
III	15.7	15.0	34.5	26.0	183	89	15.8	15.3	38.7	32.0	103	146
IV	17.3	17.0	43.7	40.0	14	17	16.6	18.4	44.1	57.8	11	30
V	18.0	19.7	47.0	57.0	1	5	24.0	21.9	134.3	103.0	3	18
VI	22.1	23.4	84.0	101.0	2	4	25.5	25.4	136.0	159.0	3	14
VII	—	27.7	—	173.0	—	2	—	28.5	—	227.0	—	11
VIII	29.3	29.7	192.0	218.0	1	1	29.0	30.8	232.0	288.0	1	11
IX	—	32.7	—	295.0	—	1	31.0	33.7	432.0	383.0	1	10
X	—	34.5	—	355.0	—	1	—	35.4	—	450.0	—	9
XI	37.2	35.7	392.0	405.0	1	1	34.8	36.8	423.5	500.0	2	9
XII	—	—	—	—	—	—	42.2	39.6	611.5	600.0	2	6
XIII	—	—	—	—	—	—	39.5	38.7	703.0	660.0	1	3
XIV	—	—	—	—	—	—	41.8	41.1	—	790.0	—	1

[1] See text for explanation

knowledge is available to show how extreme the movements may have been during the intervening time. At the other extreme, a male fish free less than one week traveled over 33 miles from the tagging site. It is obvious that tag returns are affected by location of fishing effort, and not necessarily where the majority of the fish of any one tagging series are located. Thus, all returns should be accepted with this reservation.

In general, seasonal movements were similar, with some exceptions, to the general pattern of movements first outlined by Vladykov and Wallace (1938:67–86 and 1952:164–75) and summarized by Raney (1952:25) and recently described by Whitney (1961:35) for striped bass caught and tagged from non-selective pound nets in Chesapeake Bay. The latter gear as a rule are known to trap small striped bass, and fish beyond 20 inches long are infrequent. The tagged fish reported herein, also based on relatively young fish, indicated the following seasonal pattern: (a) spring—generally upstream movement in the tributaries and bay, with localization at the tagging site of small, presumably immature females; (b) summer—general dispersal downstream into the bay and river mouths into shallow and surface waters as evidenced by hook and line recaptures, and some interchange between estuaries, but also with some localization of individuals at the tagging site; (c) autumn—some movement downstream in the bay to deep water, upstream in certain tributaries, but with further persistent localization at the tagging site; and (d) winter—concentrations in the deeper waters of tributaries and bay where fish were tagged but with minor yet definite, movements for short distances. The principal difference between these results and those given by Vladykov and Wallace was the significant numbers of recaptures of tagged fish at the tagging site during all seasons. Vladykov and Wallace discuss little apparent localization of recapture in their paper, although the same results as reported herein are suggested in the tables given by Vladykov and Wallace (1952:166–70). The present study corroborates the observation by these authors (p. 172–4) that the percentage of pan-sized fish leaving the bay for outside coastal waters is very small (Table 9).

Differences in local stocks of fish as reflected by movements:—The preponderance of local recaptures lends further credence to the belief that Chesapeake Bay

TABLE 5.—Comparison of growth rate studies of the striped bass, *Roccus saxatilis*, in various regions.

Age Group	Present Study Mean Calculated Fork Lengths Maryland		Robinson (1960:288) Mean Calculated Fork Lengths. Sexes Combined	Fitzpatrick and Cookson (1958:10) Mean Measured Fork Lengths Sexes Combined	Stevens (1957:15–6) Mean Calculated Fork Lengths[2] Sexes Combined	Scruggs (1957:154) Mean Calculated Fork Lengths[2] Sexes Combined	Morgan and Gerlach (1950:20) Mean Measured Fork Lengths. Sexes Combined	Merriman (1941:30, 70) Mean Calculated Fork Lengths to 4th year. Measured Fork Lengths from a 5th to 9th Years. Sexes Combined	Pearson (1938:839) Frequency Distribution. Sexes Combined	Scofield (1931:41) Mean Calculated Fork Lengths. Sexes Combined	Scofield (1931:35) Mean Measured Fork Length. Females Only
	Males	Females[1]	California	Massachusetts	South Carolina	South Carolina	Oregon	New England States	Maryland	California	California
I	5.3	4.9	4.1	8.9	8.0	6.7	—	4.9	4.0	4.2	3.8
II	11.7	11.5	9.8	11.2	14.8	14.0	—	9.2	10.0	9.8	10.4
III	15.0	15.3	15.3	12.5	18.6	18.3	14.5	14.4	15.0	14.6	13.6
IV	17.0	18.4	19.6	15.0	21.5	20.8	19.0	17.7	18.5	17.8	18.0
V	19.7	21.9	22.9	17.6	24.2	23.6	22.7	20.9	—	20.8	21.1
VI	23.4	25.4	25.7	19.9	26.8	25.8	25.0	24.0	—	23.2	23.8
VII	27.7	28.5	27.9	21.9	28.4	28.3	27.3	27.0	—	25.4	27.0
VIII	29.7	30.8	29.9	23.1	—	30.4	28.8	29.5	—	—	30.6
IX	32.7	33.7	32.3	24.1	—	32.5	30.0	32.3	—	—	31.3
X	34.5	35.4	—	25.1	—	—	—	—	—	—	34.2
XI	35.7	36.8	—	25.9	—	—	—	—	—	—	37.3
XII	—	39.6	—	26.9	—	—	—	—	—	—	39.0
XIII	—	38.7	—	27.5	—	—	—	—	—	—	38.6
XIV	—	41.1	—	27.9	—	—	—	—	—	—	40.6
XV	—	—	—	28.2	—	—	—	—	—	—	41.3
XVI	—	—	—	28.4	—	—	—	—	—	—	42.5
XVII	—	—	—	29.3	—	—	—	—	—	—	—
XVIII	—	—	—	30.9	—	—	—	—	—	—	—
XIX	—	—	—	29.1	—	—	—	—	—	—	—
Principal gears	Largely stake and drift gillnets.[3]		Hook and line.[4]	Hook and line.[4]	Anchor gillnets.[3]	Hook and line[4] and gillnets.[3]	Largely gillnets.[3]	Pound net, haul seines and hook and line.[4]	Hook and line[4]	Haul seine.[4]	Haul seine.[4]

[1] Contains a mixture of females and fish of unknown sex. See text for explanation.
[2] Total lengths converted to fork lengths by the conversion factor of 0.93, derived from a study of Maryland striped bass.
[3] Size selective fishing gear.
[4] Non-selective fishing gear, except as affected by size limits.

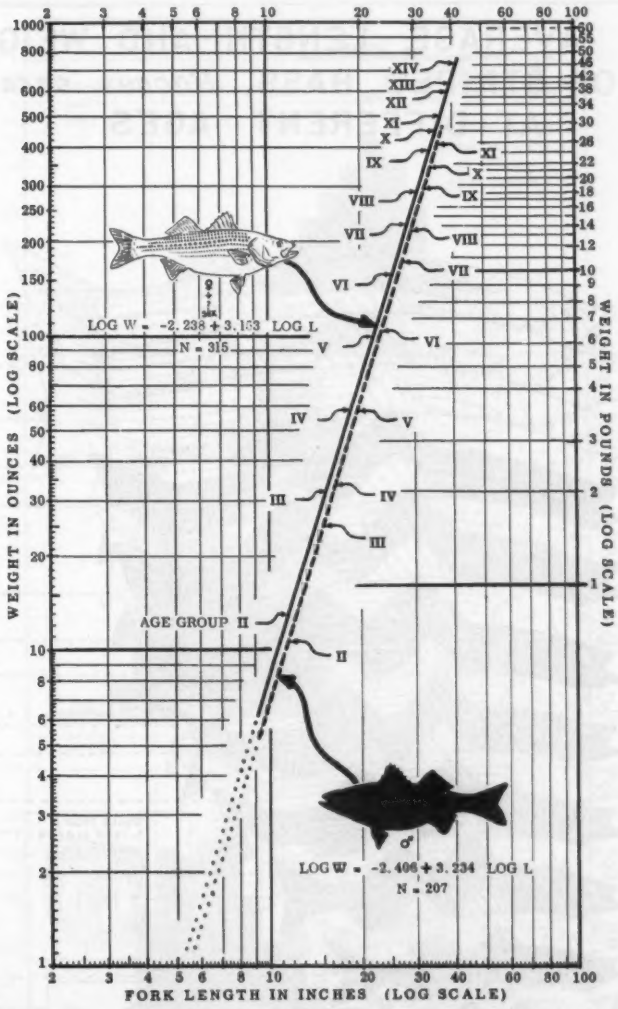

Fig. 3.—Length, weight and age relationship of striped bass, *Roccus saxatilis*, with age group of the two sexes located on the line according to average length at each age based on fish caught in Chesapeake Bay, Maryland.

striped bass may be composed of distinct stocks of fish, perhaps the result of local spawning, that maintain their integrity at least during the first two or three years of life. This generalization certainly cannot be expanded to suggest that these stocks remain localized throughout their life. Chapoton and Sykes (1961:17–8) have shown that most large striped bass between 6 and 54 pounds were not recaptured locally but migrated along the Atlantic Coast. Tagging studies could verify such a hypothesis of local stocks, although it is necessary to concentrate on marking fish on the spawning grounds of specific rivers or areas where they are believed to be different. Unfortunately, the tagging sites were not entirely restricted to spawning areas; some

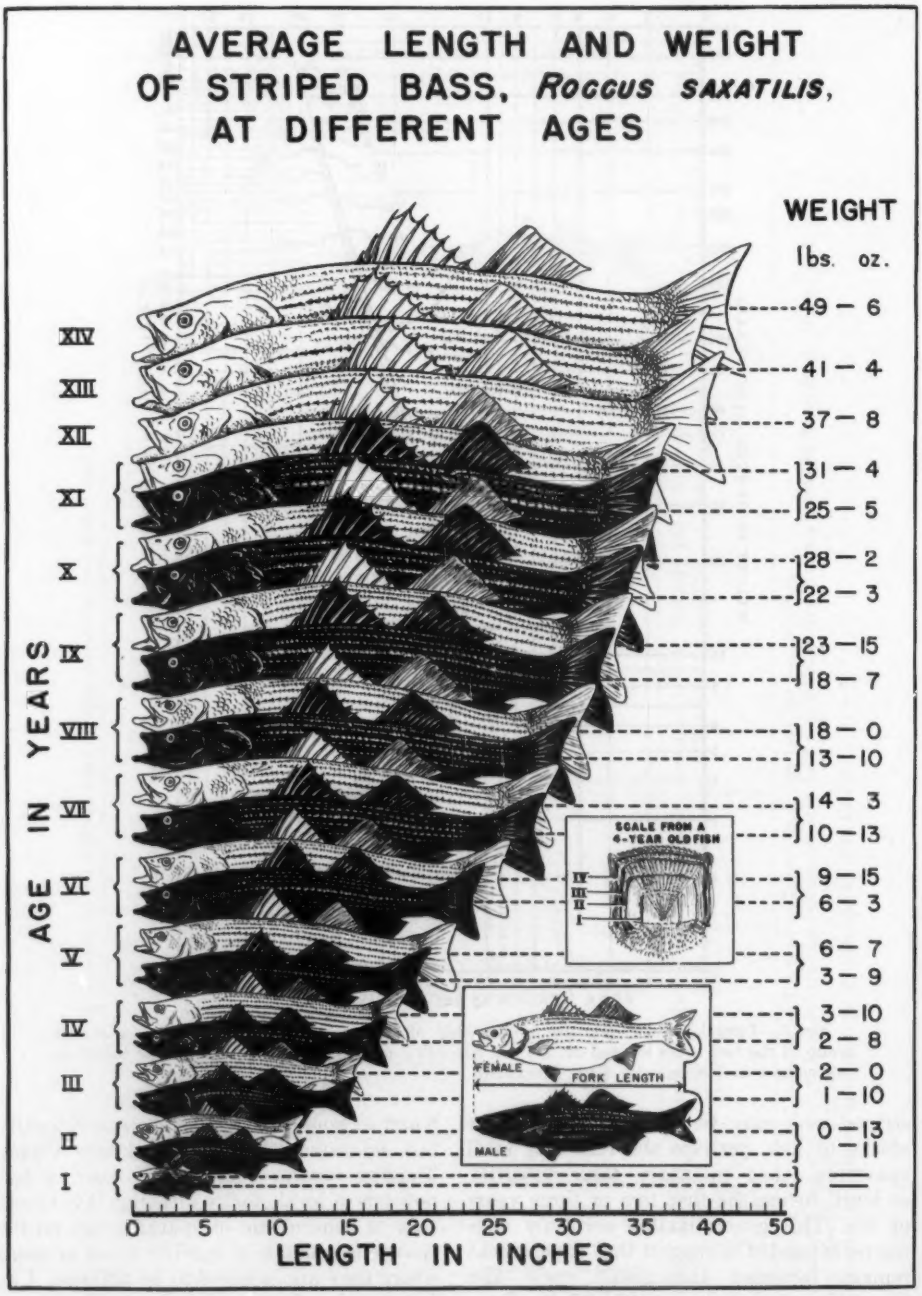

Fig. 4.—Graphic summary of average calculated length and weight of striped bass, *Roccus saxatilis*, at different ages, based on fish tagged in 1957 and early 1958 in Chesapeake Bay, Maryland.

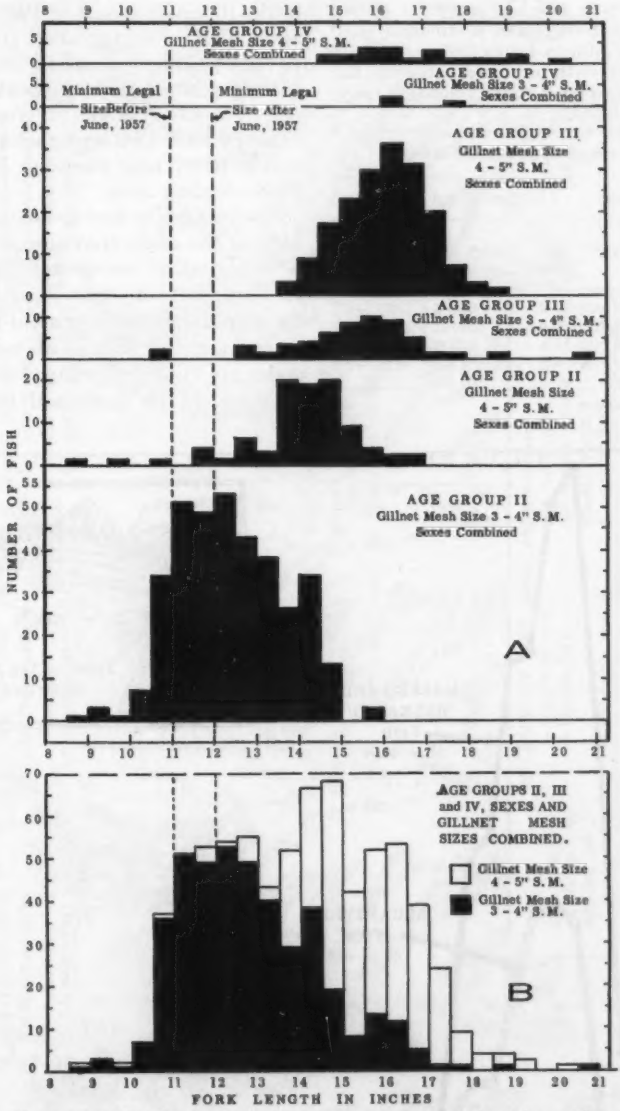
AGE GROUP IV
Gillnet Mesh Size 4 - 5" S.M.
Sexes Combined
AGE GROUP IV
Gillnet Mesh Size 3 - 4" S.M.
Sexes Combined
Minimum Legal Size Before June, 1957
Minimum Legal Size After June, 1957
AGE GROUP III
Gillnet Mesh Size 4 - 5" S.M.
Sexes Combined
AGE GROUP III
Gillnet Mesh Size 3 - 4" S.M.
Sexes Combined
AGE GROUP II
Gillnet Mesh Size 4 - 5" S.M.
Sexes Combined
AGE GROUP II
Gillnet Mesh Size 3 - 4" S.M.
Sexes Combined
A
NUMBER OF FISH
AGE GROUPS II, III and IV, SEXES AND GILLNET MESH SIZES COMBINED.
Gillnet Mesh Size 4 - 5" S.M.
Gillnet Mesh Size 3 - 4" S.M.
B
FORK LENGTH IN INCHES

Fig. 5.—Frequency distributions of three age groups of striped bass, *Roccus saxatilis*, taken by two major gillnet mesh size groups in the commercial gillnet fishery during spring 1957 in Chesapeake Bay, Maryland. (S.M. = Stretched Mesh).

were also wintering and feeding areas. Thus, the tagging sites were designated ecologically in terms of seasonal use as follows: (a) upper Chesapeake Bay off Aberdeen Proving groups and Worton Point in March, 1957—post-wintering area: (b) Potomac River off Popes Creek and Port Tobacco Beacon in March 1957—post-wintering area about 10 miles below the spawning area (Mansueti, 1959B:12); (c) Elk River and Chesapeake and Delaware Canal in April and May 1957—spawning area; (d) Chesa-

TABLE 6.—Growth in four age groups of striped bass, *Roccus saxatilis*, taken in different sized meshes of stake gillnets during 1957 to illustrate compensatory growth in faster growing fish taken in the larger mesh sizes. Number of specimens in parentheses.

Age Group	Mean Calculated Fork Length in Inches					
	Males			Females and unknown sex[1]		
	3–4″	4–5″	Difference	3–4″	4–5″	Difference
I	5.9 (96)	5.7 (123)	−0.2	5.3 (293)	5.4 (168)	+0.1
II	12.5 (96)	11.9 (123)	−0.6	12.1 (293)	11.4 (168)	−0.7
III	14.3 (13)	15.6 (78)	+1.3	13.4 (10)	15.7 (119)	+2.3
IV	17.0 (2)	17.3 (10)	+0.3	14.9 (1)	17.1 (13)	+2.2

[1] See text for explanation.

peake Bay near mouth of Patuxent River in June 1957—feeding area; (e) Choptank River at Ganey's Landing in April 1957—spawning area; (f) Chesapeake Bay Channel from Cove Point to Worton Point in January 1958—wintering area; and (g) Patuxent River near Sheridan Point in April 1958—feeding area.

The possibility that spawning fish may return to the same spawning area each year is indicated by recaptures listed in Table 7. Thus, out of eight classifiable returns six were found in the general region of previous spawning. Almost all were males. Females are virtually lacking because the gillnets are set for pan-sized fish, hence the

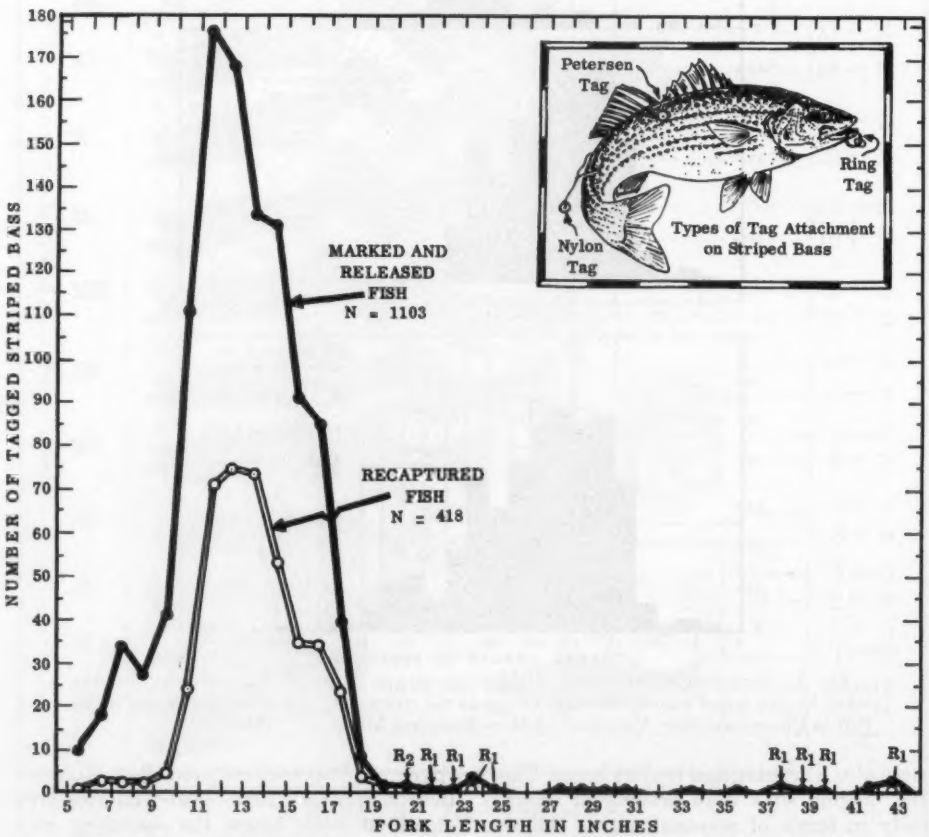

Fig. 6.—Comparison of size frequency polygons of released, with recaptured, striped bass, *Roccus saxatilis*, tagged in 1957 and early 1958 in Chesapeake Bay, Maryland. Sexes and all tag types combined and measurements based on sizes at tagging.

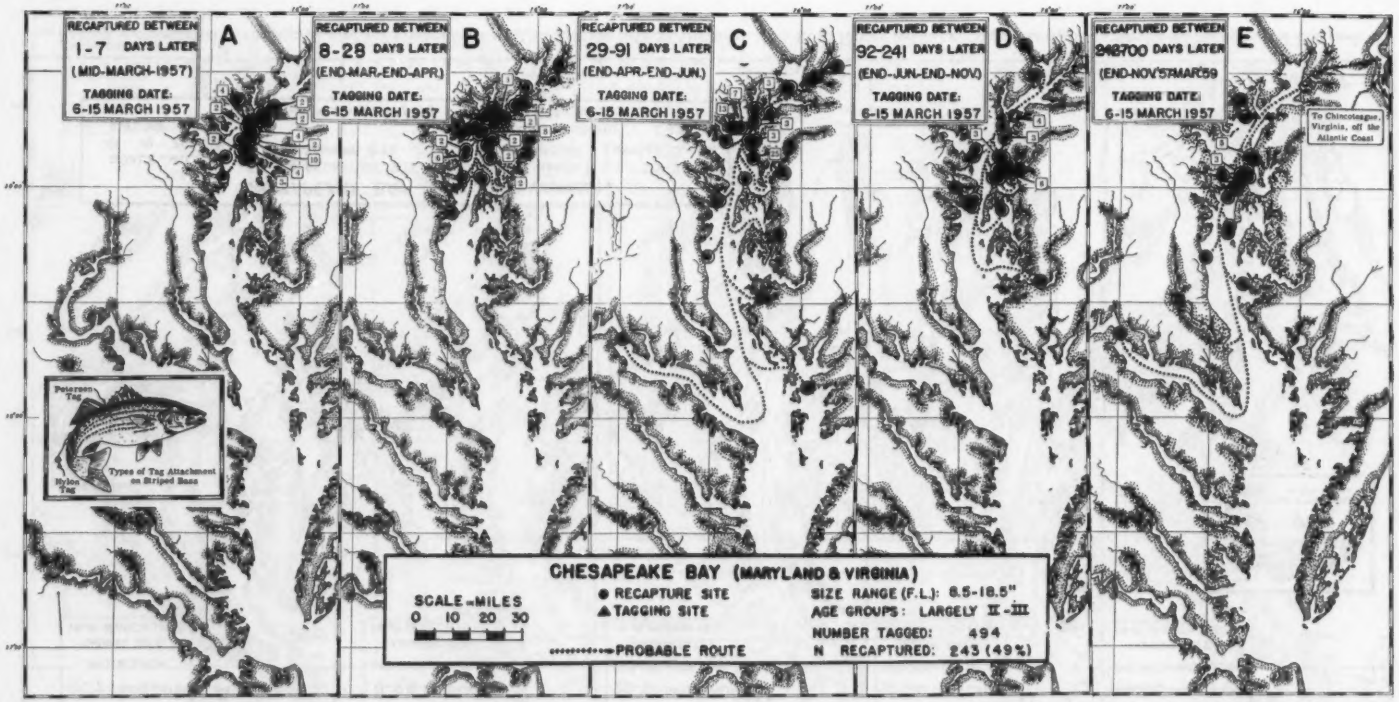

FIG. 7.—Progressive dispersal and movements from the release site in upper Chesapeake Bay, off Aberdeen Proving Grounds and Worton Point, Maryland, of tagged and recaptured striped bass, *Roccus saxatilis*.

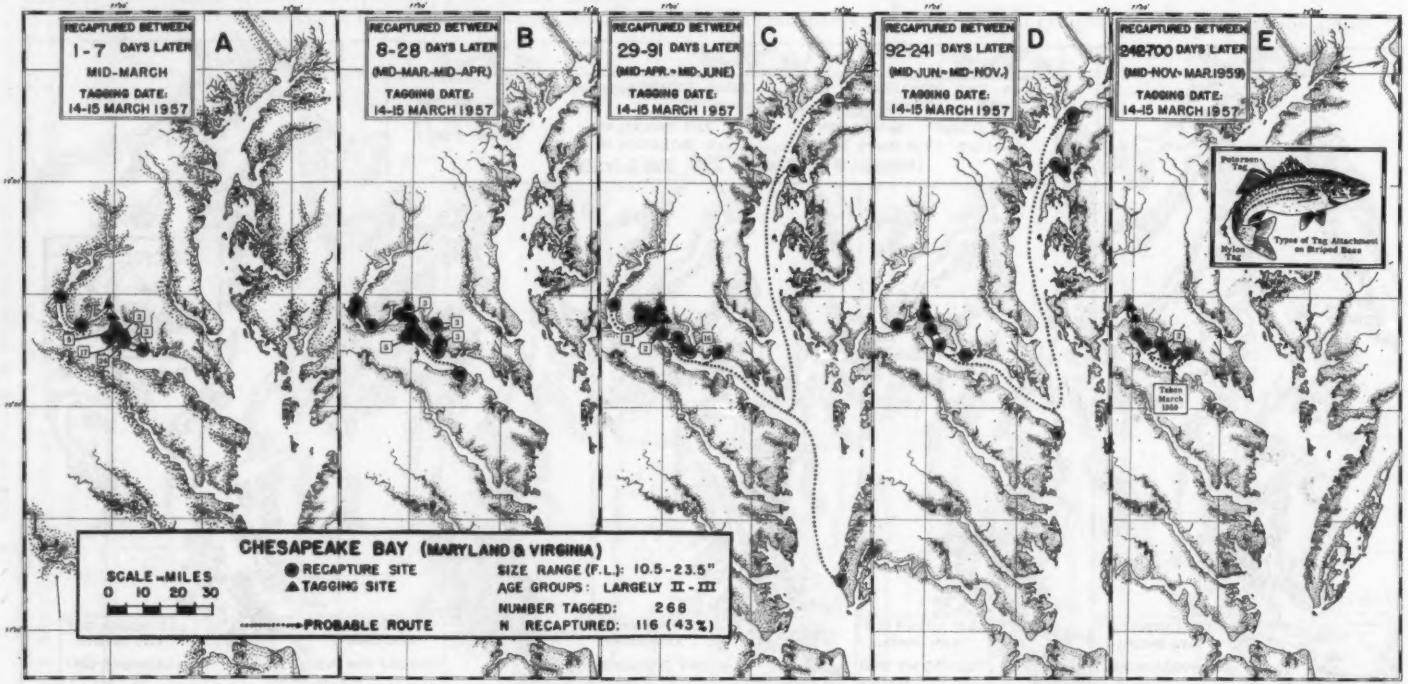

FIG. 8.—Progressive dispersal and movements from the release site in the mid-Potomac River estuary, Maryland, of tagged and recaptured striped bass, *Roccus saxatilis*.

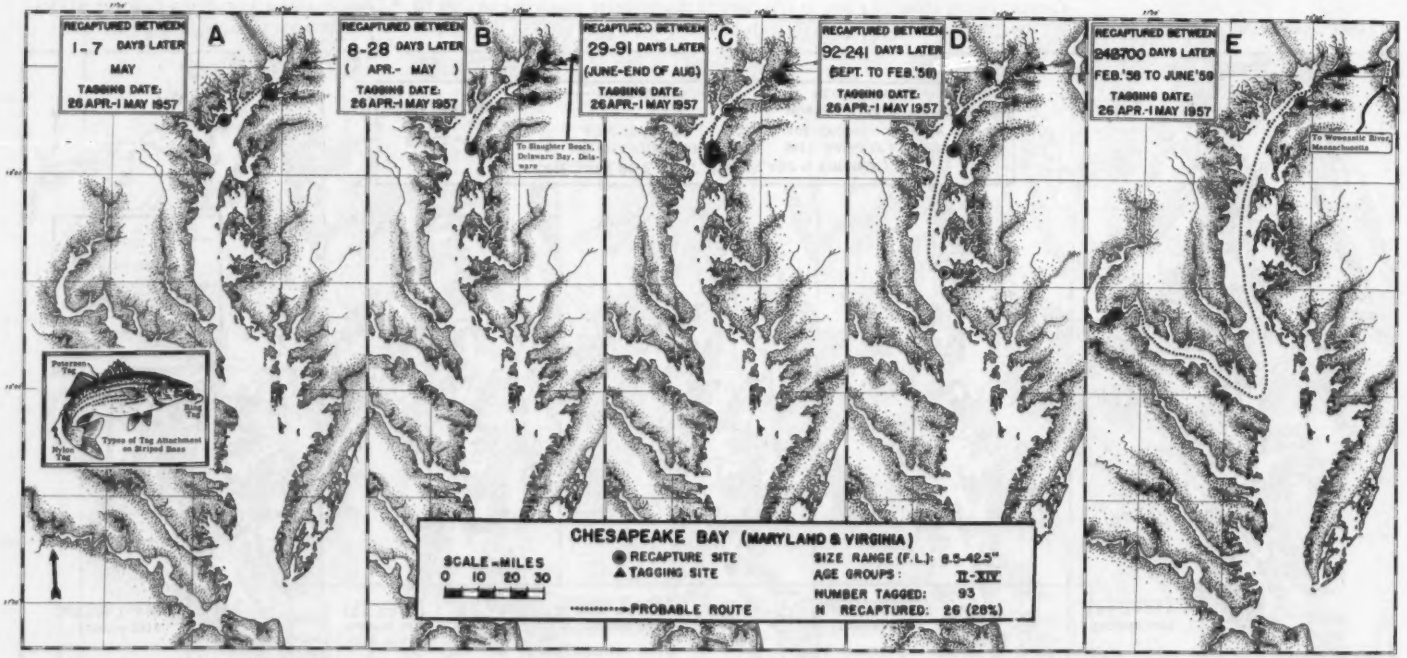

FIG. 9.—Progressive dispersal and movements from the release site in the Elk River and Chesapeake and Delaware Canal, Maryland, of tagged and recaptured striped bass, *Roccus saxatilis*.

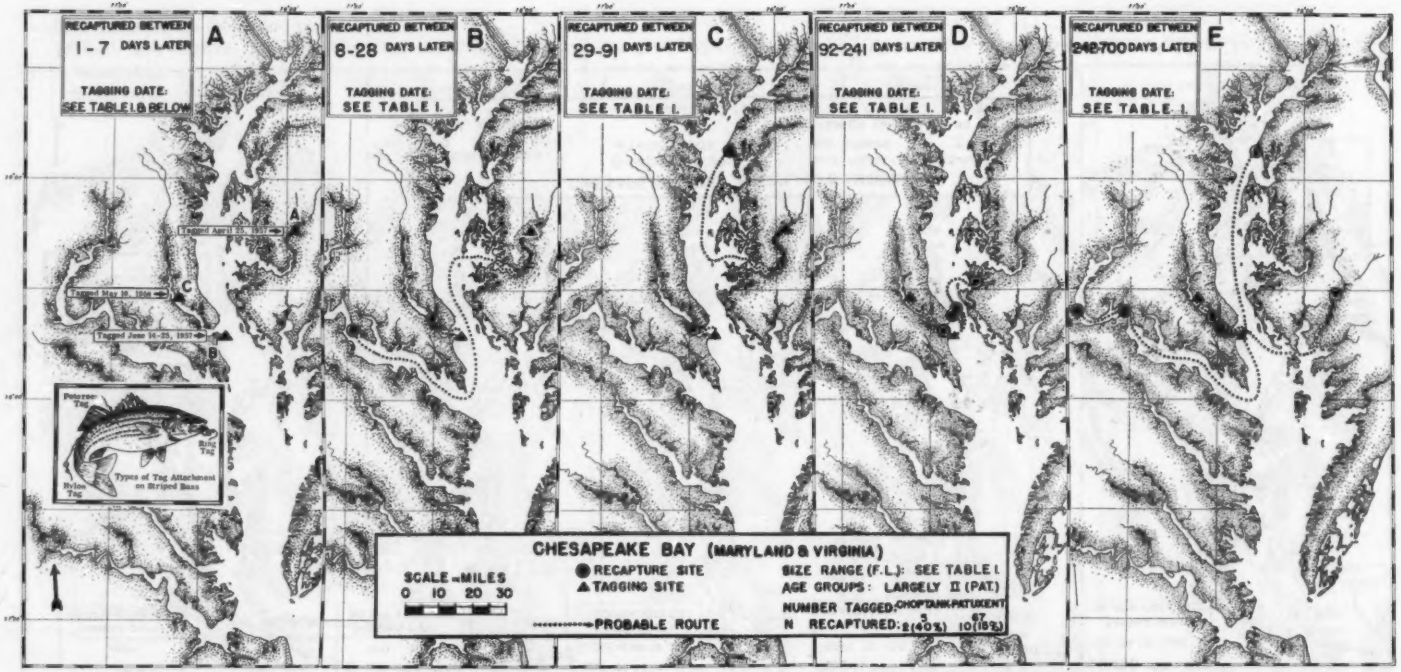

FIG. 10.—Progressive dispersal and movements of tagged and recaptured striped bass, *Roccus saxatilis*, from the release sites in Chesapeake Bay: (A) in the mid-Choptank River estuary; (B) off the Patuxent River mouth; and, (C) in the Patuxent River estuary.

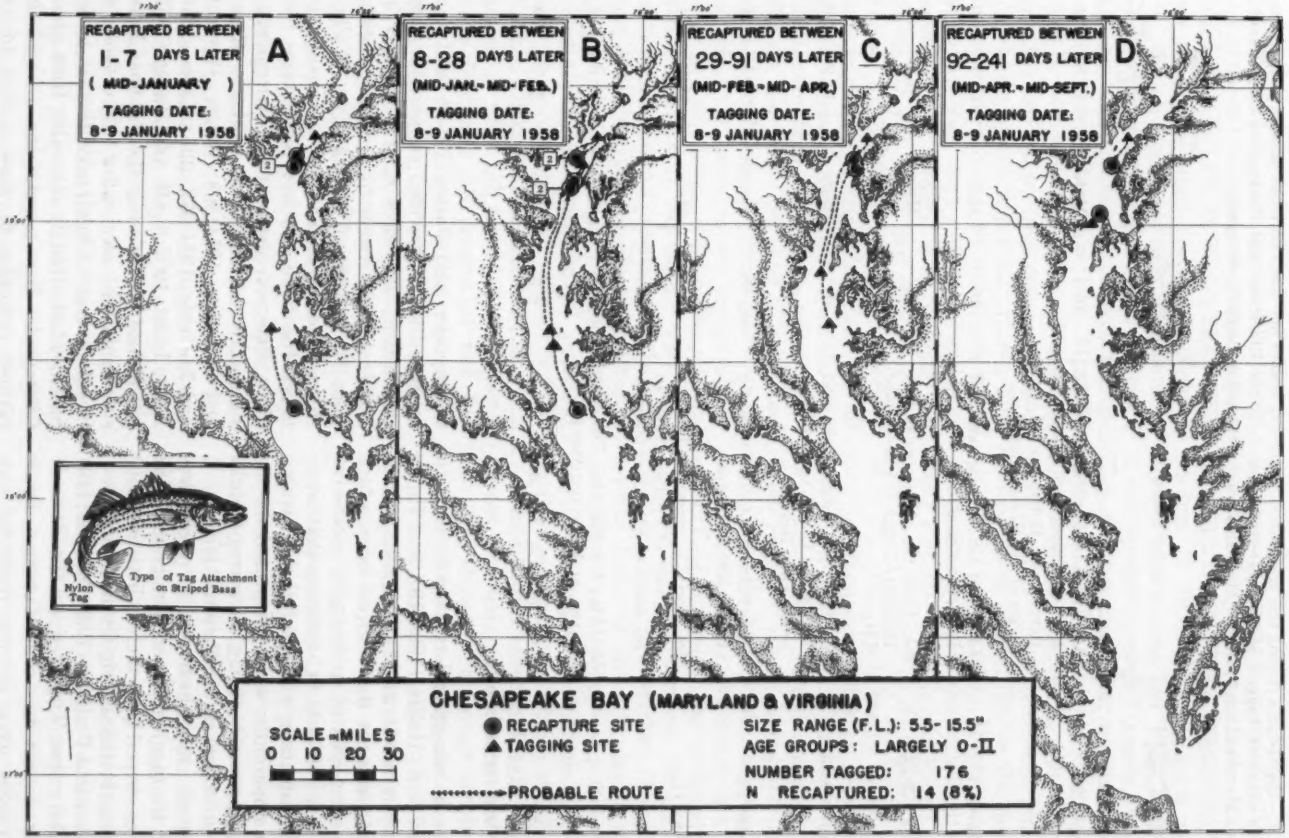

FIG. 11.—Progressive dispersal and movements from the release sites at various mid-Chesapeake Bay stations, Maryland, of tagged and recaptured striped bass, *Roccus saxatilis*.

TABLE 7.—Recaptures during the presumable spawning season one and two years later of striped bass, *Roccus saxatilis*, tagged on the spawning grounds in the Elk River and Chesapeake and Delaware Canal, Maryland, in April and May, 1957, and arranged by tagging sequence.

Date of Recapture Year/Mo./Day	Locality of Recapture	Distance from Tagging and Spawning Site in Miles	Data at Tagging		
			Sex	Length Inches (F.L.)	Weight Ounces
1958, April 24.	Md., Kent Co., upper Chesapeake Bay, at mouth of Sassafras River, nr. Betterton (6 mi. south of Elk River mouth).	16	Male	13.8	21
1958, April 21.	Md., Cecil Co., Chesapeake and Delaware Canal.	0	Male	16.4	30
1958, Apr. 18–22.	Md., Cecil Co., Chesapeake and Delaware Canal, at Chesapeake City.	0	Male	18.8	54
1958, Apr. 10–25.	Md., Cecil Co., Chesapeake and Delaware Canal, nr. Chesapeake City Bridge.	0	Male	15.9	30
1958, June 13.	Mass., Plymouth Co., Weweantic River, Nr. Wareham.	ca. 635	Female? [1]	22.8	104
1958, May 11.	Md., Cecil Co., Sassafras River, 2 miles west of Fredericktown (9 mi. south of Elk River mouth).	18	Male	16.2	34
1958, April 8.	Md.-Va., Charles Co., Potomac River, at Maryland Point.	ca. 150	Male	16.3	33
1959, April 1.	Md., Cecil Co., Elk River.	0.5	Male	15.7	30

[1] See text for explanation.

chances of snagging large spawners with tags are low. Hollis (1960:19) and Hollis and Davis (1955:2) also suggested from their tag returns that striped bass return to the same area of spawning in successive years. Fig. 8B and 8C indicate that some of the fish tagged before the spawning season apparently were recaptured on the spawning grounds during the spring months of the same year on the Potomac River.

Although the clustering of recaptures around the tagging site may suggest specific stocks of striped bass, there is little evidence that these stocks are rigidly self-contained. Vladykov and Wallace (1938:76, 1952:149–50, 170–1) first suggested on the basis of fin ray counts that the Potomac River striped bass were distinct from the two other major populations, namely, the upper Chesapeake and James River, and that tagging studies provided support for these conclusions. The more restricted study by Lund (1957:9) came to the same conclusion. The returns of Vladykov and Wallace showed, however, that some exchange between the river and bay populations took place. Extensive meristic and morphometric studies by a number of workers (Raney and de Sylva, 1953:508; Raney, Woolcott and Mehring, 1954:378, 395; Lewis, 1957: 7, 12; Lund, 1957:8, 10; and Raney, 1957: 93) indicated that while the Potomac River subpopulation may differ from those of rivers in lower Chesapeake Bay it is apparently not strongly separable from upper Chesapeake Bay populations. One of the earliest examples to show a lack of extensive interchange is Pearson (1933:16,

and 1938:843–5) who tagged 305 striped bass in upper Chesapeake Bay at Annapolis during summer 1931. Of 89 fish recaptured, only nine were taken south of Annapolis. The tagging reported herein off Aberdeen and Worton Point (Fig. 7) also indicated relatively little movement between the upper and lower Chesapeake Bay. Mansueti (1956:5) showed that most of the fish tagged in mid-winter from deep water later moved largely into upper bay waters. This is further corroborated by recaptures shown in Fig. 11. Figs. 7–11 show some exchange between river systems with virtually no egress into the lower bay. Vladykov and Wallace (1952:165–9) described a southward migration of upper bay fish, but all of their tagged samples came from the mid-Chesapeake area below Annapolis, which suggests that their fish had a lower bay origin. In addition to the explanation of the relatively homogeneous nature of the upper bay population, it is possible, as suggested above, that movements were generally limited in the present study because most of the marked fish were restricted to age groups II, III and IV which, as suggested above, apparently do not undertake large scale movements. Vladykov and Wallace (1952:174) showed that only 1.5 percent of 1,869 fish tagged in mid-Chesapeake Bay and 0.3 percent of 662 fish marked in the Potomac River migrated out of the bay. A perusal of their table on p. 173 shows that most of these could be classified in age groups II–IV. Of 90 striped bass under 9″ F.L. tagged in 1957–8, virtually all recaptures (10) were taken locally. Thus, the majority of striped bass younger than age group IV would be expected to remain together localized in their natal area, and not undertake long migrations.

Long-range movements inside and outside Chesapeake Bay:—Only five of the recaptured fish ventured out of the Maryland part of Chesapeake Bay: (a) two specimens from the Virginia part of Chesapeake Bay (Fig. 8C and 8D; see Mansueti, 1958:22, for details); and (a) three specimens left Chesapeake Bay as follows: (1) recaptured in Massachusetts, marked with a nylon streamer tag on April 26, 1957 on the spawning grounds in the Elk River. It was caught by an angler near Wareham, Plymouth County, in the Weweantic River, on June 13, 1958. When tagged it weighed 6 pounds, 8 ounces, but when recaptured it was reported to weigh 7 pounds, 14 ounces. This fish, sex unknown, was free for 444 days and traveled north approximately 635 miles from the tagging site; (2) recaptured in Delaware, a ripe male marked with a Petersen disk on May 1, 1957 on the spawning grounds in the Elk River. It was recaptured about 65 miles from the release site by a stake gillnetter off Slaughter Beach, Sussex County, at mouth of Delaware Bay on May 23, 1957. When tagged it weighed 2 pounds, 10 ounces, and when recaptured it was reported to weigh 2 pounds, 6 ounces; (3) recaptured off Virginia, marked with a nylon streamer tag on March 13, 1957 in upper Chesapeake Bay off Aberdeen Proving Grounds, it was recaptured in a pound net off Chincoteague in Queen Sound Channel, Accomack County, on November 10, 1957. The male fish weighed 19 ounces at tagging and was free 243 days and presumably traveled south down Chesapeake Bay, went around the Virginia Capes and headed northward, a distance of 230 miles.

Relationship between length and distances traveled:—Preliminary analysis of the data showed that larger striped bass traveled somewhat longer distances than smaller individuals (Mansueti, 1958:22). Additional returns have sustained this general conclusion. Table 8 suggests this fact and these principal conclusions:

1. A linear regression of average distances traveled by striped bass of combined sexes shows a relationship between size and distance traveled (Fig. 12). This trend, however, is not evident when mean distances traveled by sexes and tag types are perused in relation to the one inch size group (Table 8).

2. Nylon streamer tagged striped bass generally traveled further on the average than those tagged with Petersen pin tags. Table 1 shows that the difference is not due to a larger average size in the nylon-tagged fish over those tagged with Petersen disks. It is due to the higher selective removal of

TABLE 8.—Summary of mean distances in miles traveled by tag type and size category of striped bass, *Roccus saxatilis*, tagged in Chesapeake Bay, Maryland during 1957 and early 1958.

Fork length (inches)	Males									Females and unknown sex[3]									Grand Mean Miles (Sexes combined)	N
	Nylon tag			Petersen tag			Combined[1]			Nylon tag			Petersen Tag			Combined[1]				
	Miles		N[2]	Miles		N	Miles		N	Miles		N	Miles		N	Miles		N		
	Mean	Range		Mean	Range		Mean	Range		Mean	Range		Mean	Range		Mean	Range			
5–6	—	—	—	—	—	—	—	—	—	8.0	—	1	—	—	—	8.0	—	1	8.0	1
6–7	—	—	—	—	—	—	—	—	—	7.3	6.0–8.0	3	—	—	—	7.3	6.0–8.0	3	7.3	3
7–8	—	—	—	—	—	—	—	—	—	3.7	1.0–8.0	3	—	—	—	3.7	1.0–8.0	3	3.7	3
8–9	—	—	—	—	—	—	—	—	—	8.0	8.0	2	11.0	—	1	9.0	8.0–11.0	3	9.0	3
9–10	—	—	—	—	—	—	—	—	—	30.0	—	1	10.2	4.0–18.0	4	14.2	4.0–18.0	5	14.2	5
10–11	11.8	9.5–14.0	2	19.3	11.0–45.0	6	17.4	9.5–45.0	8	17.5	8.0–30.0	4	10.4	2.0–18.0	12	12.2	2.0–30.0	16	14.0	24
11–12	16.0	2.0–41.0	4	19.2	2.5–37.0	9	18.2	2.0–41.0	13	12.8	2.5–33.0	14	16.1	2.5–32.0	44	15.3	2.5–33.0	58	15.8	71
12–13	11.6	2.5–16.0	7	14.2	2.0–44.0	6	12.8	2.0–44.0	13	32.4	4.0–147.0	24	12.3	1.0–80.0	38	20.1	1.0–147.0	62	18.8	75
13–14	59.0	2.0–230.0	7	13.7	1.5–33.0	15	28.1	1.5–230.0	22	17.7	4.0–74.0	24	13.7	2.0–113.0	28	15.6	2.0–113.0	52	19.3	74
14–15	7.5	0.0–13.0	6	20.8	2.0–146.0	12	16.4	0.0–146.0	18	26.0	2.5–146.0	14	17.8	2.0–153.0	19	21.3	2.0–153.0	33	19.6	51
15–16	3.6	4.0–32.0	7	18.1	2.0–37.0	10	14.6	2.0–37.0	17	32.1	6.0–134.0	7	11.0	4.0–29.0	11	19.2	4.0–134.0	18	17.0	35
16–17	90.0	4.0–176.0	2	12.0	3.5–33.0	10	33.2	3.5–176.0	15[1A]	26.3	6.0–130.0	8	12.1	2.5–25.0	11	17.4	2.5–130.0	19	24.4	34
17–18	13.5	3.0–21.0	4	27.2	7.0–66.0	5	22.2	3.0–66.0	10[1B]	12.0	8.0–27.0	8	9.0	4.0–14.0	1	10.8	4.0–27.0	13	15.8	23
18–19	—	—	—	3.5	—	1	3.5	—	1	—	—	—	—	—	—	—	—	—	3.5	1
19–20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20–21	—	—	—	8.0	—	1	8.0	—	1	—	—	—	—	—	—	—	—	—	8.0	1
21–22	—	—	—	28.0	—	1	28.0	—	1	—	—	—	—	—	—	—	—	—	28.0	1
22–23	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
23+	—	—	—	—	—	—	—	—	—	63.5	—	1	23.0	—	1	57.5	13.0–138.0	4[1C]	57.5	4
5–16	21.1	0.0–230.0	33	17.4	1.5–146.0	58	18.7	0.0–230.0	91	21.9	1.0–147.0	97	14.0	1.0–153.0	157	17.0	1.0–153.0	254	17.5	345
16–23	31.5	3.0–176.0	6	16.4	3.5–66.0	18	23.8	3.0–176.0	28[1]	54.6	6.0–130.0	17	11.1	2.5–25.0	18	32.2	2.5–130.0	35[1C]	28.5	63
Total	23.8	0.0–230.0	39	17.1	1.5–146.0	76	20.7	0.0–230.0	119	26.8	1.0–147.0	114	13.7	1.0–153.0	175	19.4	1.0–153.0	292	19.2	408

[1] Contains jaw ring tag where designated; [1A] = 3 jaw ring tag returns ($\bar{X}$ = 49.7; range 26–80 mi.); [1B] = 1 jaw ring tag return 32 mi.; [1C] = a 37 inch female 138 miles; a 38 inch female 62 miles; a 42 inch female 17 miles.

[2] Number of fish.

[3] See text explanation.

fish by the latter tags, thereby reducing the average distance traveled.

3. Larger striped bass of both sexes, grouped at 16 inches F.L. and above, traveled 11 miles more, on the average, than did those in the sample grouped below this size (Table 8).

4. Male striped bass 16 inches and above traveled over five miles further than those below this length, while females and fishes of unknown sex 16 inches and above traveled over 15 miles further on the average. These results and others given above have probably been affected by differences in fishing intensity within the between areas, seasonal fishing patterns, and gear catching them.

Significance of Tag Returns

The recapture of tagged fish in close proximity to the release sites suggests that long-range movements are carried out by a very small number of striped bass. Preliminary results of other studies (Hollis and Davis, 1955:2, and Massmann, et al, 1959:44) suggested that this is true throughout Chesapeake Bay and its tributaries. All tagging studies of young striped bass have shown that only a few fish migrate out of Chesapeake Bay (Table 9). Chapoton and Sykes (1961:18) showed that with large striped bass, however, this generality is not true, a conclusion shared by Hollis (1960: 20). The results have practical importance for these reasons: (a) several of the young age groups (II, III and IV) are almost exclusively available to Chesapeake Bay anglers and netters before any important segment of fish leave the Bay; (b) there is little exchange between local groups of fishers during the spring months when commercial fishing is at its height, so that while an efficient fisherman can significantly affect a local concentration, he cannot seriously reduce the numbers of the bay-wide population; and (c) although there is enough local movement to provide fluctuations in availability to anglers and netters, it is probably far less than would result if each local group of fish undertook large-scale migrations.

The results, furthermore, suggest several problems. Summarizing the observations

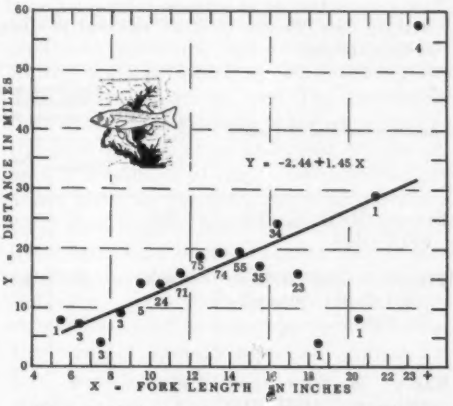

Fig. 12.—Relationship between length of striped bass, *Roccus saxatilis*, and mean distance traveled. The numbers below each dot indicate the sample size of fish in each group of average measurements. Sexes and tagged fish from all areas combined.

of Merriman (1941:30–1), Vladykov and Wallace (1952:174, 177), and other data, Raney (1952:23) concluded that most of the basic migratory stock along the Atlantic Coast is produced in Chesapeake Bay (see also Sykes, 1958B:375). He also stated that the migratory stock, mostly from age group II and older fish, was a relatively small portion of the Chesapeake population but contributed a large part of the northern striped bass population. Merriman (1941: 44) and Fitzpatrick and Cookson (1958: 10–1) encountered relatively few striped bass less than two years old. In view of the consistent record of an almost insignificant percentage of tagged fish among age groups II through IV that have left Chesapeake Bay, it is probable that the contribution from Chesapeake Bay is relatively small except during years when large dominant year classes enter the fishery. Nevertheless, there is some evidence that large year-classes in Chesapeake Bay have made important contributions to northern waters during the last two decades. In these cases an insignificant percentage of coastal migrants may represent a very significant number of available fish. These comments must also be tempered by the fact that some striped bass tagged in northern coastal waters turn up in Chesapeake Bay (see

TABLE 9.—Summary of published observations of the movement outside of Chesapeake Bay of tagged striped bass, *Roccus saxatilis*, released in Chesapeake Bay waters in relation to those recaptured within the bay.

Authority and Year of Tagging	Number Tagged	Fish Recovered Outside of Chesapeake Bay		Fish Recovered Inside of Chesapeake Bay		Remarks on Size and Age of Fish[1]
		Number	Percent	Number	Percent	
Pearson (1933:16; 1938:-843–5) 1931.	305	0	—	89	29.1	10.2–15.7″. Age groups II–III.
Vladykov and Wallace (1938:67–86; 1952:167–74) 1936–37.	2869	30	1.0	928	32.0	Mode 10–15″ (63 percent). Age groups II–III. Range 5–25″ (2% over 20″)
Raney, Woolcott and Mehring (1954:393). 1949–52.	Unknown	0	—	20	Unknown	8–10″ F.L. Age group II.
Hollis and Davis (1955:2).[2] 1954–5.	457	2	0.4	78	17.1	Up to 38.5″ F.L.
Mansueti (1956:2) 1954.	31	0	—	11	35.4	9.2–15.5″ T.L. Age groups II–IV.
Massmann, et al, (1959:44).[2] 1957–58.	2439	11	0.4	Unknown	Unknown	Unknown
Chapoton and Sykes (1961:18–9) 1957–59.	206	15	7.2	12	4.7	21.0–50.0″ F.L. Age groups IV–XVIII
Whitney (1961:35–6) 1958–60.	5376[3]	1	0.0002	178	3.0	11.9–28.0″ F.L. Mostly age groups II and III.
Mansueti (This study) 1957–58.	1103	3	0.3	415	37.6	Mode 11–16″ F.L. Mostly age age groups II and III.

[1] If fork (F.L.) or total length (T.L.) is not given, then the method of measurement is unknown. Age groups (except for references by Mansueti, and Chapoton and Sykes, which are based on scale analyses) are estimated.

[2] These data were incomplete at the time of publication.

[3] Of these 4,022 were tagged and planted above Conowingo Dam, a few miles up the Susquehanna River above the head of Chesapeake Bay.

Raney, 1952:25–7 for summary; Raney, et al, 1954:385–93; and Maltezos, 1960:3–11). It is obvious that tagging studies up to now have not yet shown the true relationship between the available population and the migratory segment. The evidence in this study that the largest members move further on the average than smaller members suggests that large-scale movements of any group of fish may be deferred time-wise among dominant year-classes because the members are smaller (Merriman, 1941:25; and Raney, 1952:62), on the average, than individuals from an average or less abundant year-class.

Conclusions

(1) Age, growth, and migrations of 1103 striped bass, *Roccus saxatilis*, tagged and released during 1957 and 1958 were studied from samples caught at six different localities representing spawning, feeding, and wintering grounds, in Chesapeake Bay and tributaries in Maryland. Most specimens

were captured in size-selective commercial gillnets, while a few were caught by hook and line, otter trawl nets and haul seines during a period when the minimum size limit was 11 inches total length. The size limit was raised to 12 inches in June, 1957 shortly after a major part of the collections were made.

(2) Known male striped bass were represented in age groups II to XI, with II, III and IV, being most abundant. Females and fishes of unknown sex were combined and ranged from age group I to XIV, with II, III and IV, the most abundant. These two groups of fish grew at about the same rate for the first three years of life, based on back calculations of growth attained at each annulus on the scales. After age group IV, females consistently grew at a faster rate than the males. A new record for large size was cited for a male striped bass in its twelfth year that weighed 24.5 pounds, measured 37.2 inches F.L.

(3) Growth calculated from gillnetted fish indicated faster growing individuals are selected out by the gear so that calculated estimates during the first three years are somewhat higher than that recorded for striped bass caught by non-selective gear. The differences were about 15 percent above average. Early growth of fish caught in 3–4 inch stretched mesh and 4–5″ S.M. gillnets indicates that the latter took the largest fish, which were generally smaller during the first two seasons than fish taken in the former mesh size for the same ages. The growth phenomenon is interpreted as an example of compensatory growth.

(4) Tagging results indicate that the bulk of the 418 (38 percent) recaptured striped bass remained in the Maryland part of Chesapeake Bay. Returns were generally clustered around the tagging site, in spite of the time free, although distances of dispersal of individuals varied greatly in various parts of upper Chesapeake Bay. Less than one percent of the tagged fish were recaptured outside Chesapeake Bay, and only two were taken into the Virginia part of Chesapeake Bay.

(5) The preponderance of local recaptures suggested that each of the major tagging areas contained specific stocks resulting from local spawning that are apparently not rigidly self-contained, at least during the first several years of life. The possibility that spawning fish return to the same spawning area each year is indicated by the return of a number of tagged fish one and two years later to the spawning site on which they were tagged. None were recaptured on other spawning areas. Tagging studies also confirm meristic and morphometric studies indicating that while the Potomac River striped bass may be somewhat homogeneous, they are not strongly separable from intra-bay migration pattern or from upper bay stocks. Some evidence of exchange between the river and bay populations is available.

(6) There is some evidence that larger striped bass moved greater distances on the average than smaller individuals. Males between 5 and 16 inches F.L. traveled a mean distance of about 19 miles, while larger individuals 16–23 inches F.L. traveled 24 miles. Females and fishes of unknown sex between 5 and 16 inches traveled 17 miles, while those between 16 and 23 inches F.L. averaged 32 miles.

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Movements of Striped Bass Tagged in Virginia Waters of Chesapeake Bay[1]

WILLIAM H. MASSMANN AND ANTHONY L. PACHECO[2]

ABSTRACT

In winter and spring of 1957 and 1958, 2429 striped bass ranging in length from 7 to 35 inches were tagged in the York, James, and Rappahannock Rivers of Virginia and 675 were recaptured. Fish were recaptured by stake, drift, and anchor gillnets, fyke nets, pound nets, hook and line and an oyster dredge. Ninety-four percent of the recaptured fish were taken in the same river system in which they were tagged. Striped bass from the York River moved more extensively than those from the Rappahannock; those from the James River moved least. Twelve fish moved outside of Chesapeake Bay and were recaptured in coastal waters between Maine and North Carolina. Most fish recaptured in fall and winter were taken in the same river system in which they were tagged, while some of those recaptured in spring and summer moved considerable distances. Almost all striped bass less than 12 inches in length remained in the river system in which they were tagged. The distribution of tag returns suggested that subpopulations of striped bass were present in the York and Rappahannock and James Rivers. The James River fish rarely mixed with those from other areas in Chesapeake Bay.

Introduction

Comparison of fin rays, gill rakers, scale counts, and body measurements by Raney and de Sylva (1953), Raney, et al., (1954), Raney (1957), Lewis (1957), and Lund (1957) indicated at least three subpopulations of striped bass, *Roccus saxatilis* (Walbaum), in Chesapeake Bay, from the James River, York and Rappahannock Rivers, and upper Chesapeake Bay. Movements of separate striped bass stocks in Chesapeake Bay were determined from tagging studies by Pearson (1933), Vladykov and Wallace (1938 and 1952), and Mansueti (1958). With the exception of 342 bass tagged in the James River (Vladykov and Wallace, 1938 and 1952), all were tagged in Maryland waters. The need for extensive tagging programs in Chesapeake Bay was emphasized by Raney (1952). A tagging program was initiated in 1957 for information of the movements of striped bass in Virginia waters.

The authors wish to express their gratitude to Mr. James E. Sykes, and his colleagues on the striped bass investigations, U. S. Fish and Wildlife Service, Beaufort, North Carolina for assistance in tagging and compiling tag return data. Staff members at the Virginia Fisheries Laboratory including James Whitcomb, C. E. Richards and Frank Wojcik cooperated in field operations. We also appreciate the enthusiastic cooperation of Dr. Romeo Mansueti, Chesapeake Biological Laboratory, Solomons, Maryland, responsible for striped bass research in Maryland waters.

Tagging

A total of 2431 striped bass was tagged and released. During February, March, and April 1957, 1427 fish were tagged in the James, York and Rappahannock rivers. The numbers tagged are listed in Table 1 and release areas are shown in Fig. 1. The York River system is defined as including the York, Pamunkey and Mattaponi rivers and Mobjack Bay. The James River system includes the James and Nansemond Rivers and Hampton Roads. The Rappahannock River system includes the Rappahannock, Corrotoman, and Piankatank Rivers.

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Twenty-eight of the striped bass were obtained from stake gillnets; all others were obtained from haul seine catches. At the time of tagging, the fish were measured, weighed, and scales were obtained. Petersen disk and nylon streamer tags were used in approximately equal numbers for each one inch increment of fish length. Tagging techniques are discussed by Lewis (1961).

In February 1958, 1004 striped bass captured by otter trawl were tagged and released in the York River. The recapture rates of fish tagged in 1957 indicated that Petersen tagged fish were more vulnerable to recapture by gillnets than streamer tagged fish so in 1958 all striped bass were marked with streamer tags.

The length distributions of fish tagged in the three rivers differed. Although most were captured by haul seines of similar length and mesh size, fish from the York River were mostly larger and fish from the Rappahannock River were mostly smaller, than those from the James (Table 2). Fish captured by trawl from the York River in 1958 were smaller than those obtained by haul seines the preceding year.

TABLE 1.—Locations, dates, and numbers of striped bass, *Roccus saxatilis*, tagged in Virginia waters in 1957 and 1958.

Location	Date	Numbers and tag type		Total
		Petersen	Streamer	
York River	Feb. 13–27, 1957	200	167	367
York River	Feb. 24–28, 1958	—	1,004	1,004
James River	Mar. 19–20, 1957	214	207[1]	421
Rappahannock River	Apr. 2–5, 1957	340	297[2]	637
Total		754	1,675	2,429

[1] Two tagged fish were released without being measured.
[2] One tagged fish was released without being measured.

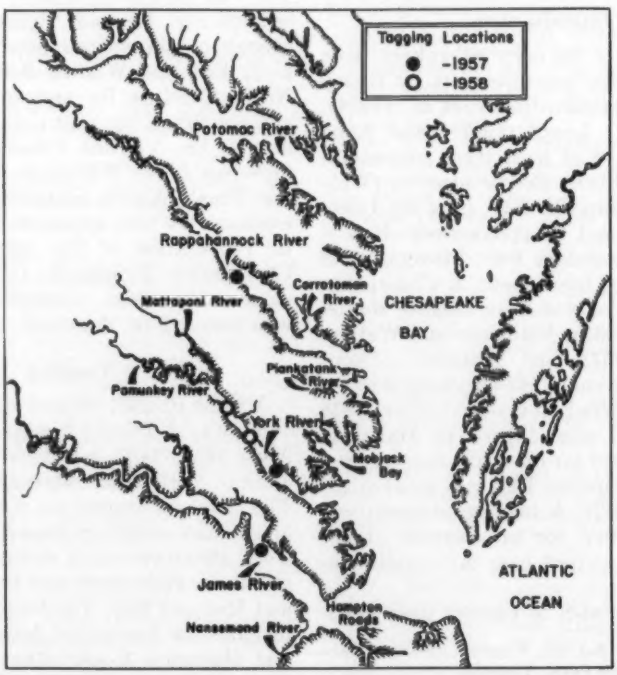

Fig. 1.—Lower Chesapeake Bay and major tributaries showing locations where striped bass, *Roccus saxatilis*, were tagged in Virginia.

TABLE 2.—Length frequency distributions of striped bass, *Roccus saxatilis*, tagged in the York, James, and Rappahannock rivers in 1957 and 1958.

Fork length interval in inches	York River 1957	York River 1958	James River 1957	Rappahannock River 1957	Total
7.0–7.9	3			1	4
8.0–8.9	10	135	2	19	166
9.0–9.9	19	214	2	119	354
10.0–10.9	20	214	23	225	482
11.0–11.9	24	161	32	155	372
12.0–12.9	55	116	60	85	316
13.0–13.9	49	49	45	15	158
14.0–14.9	30	37	63	6	136
15.0–15.9	20	27	90	2	139
16.0–16.9	12	20	63	1	96
17.0–17.9	12	13	20	1	46
18.0–18.9	19	9	8	1	37
19.0–19.9	6	5	2	—	13
20.0–20.9	5	1	5	—	11
21.0–21.9	11	—	3	1	15
22.0–22.9	9	—	1	—	10
23.0–23.9	6	—	—	1	7
24.0–24.9	8	—	—	—	8
25.0–25.9	10	2	—	2	14
26.0–26.9	8	1	—	—	9
27.0–27.9	10	—	—	—	10
28.0–28.9	7	—	—	—	7
29.0–29.9	5	—	—	—	5
30.0–30.9	3	—	—	—	3
31.0–31.9	—	—	—	—	—
32.0–32.9	3	—	—	—	3
33.0–33.9	2	—	—	1	3
34.0–34.9	1	—	—	1	2
Total	367	1,004	419	636	2,426

RECAPTURE GEAR

Tagged striped bass were recaptured by stake, drift, and anchor gillnets, fyke nets, pound nets, haul seines, hook and line, and an oyster dredge. Since the recapture rate for striped bass in smaller size classes was influenced by the type of tag used (Lewis, 1961), the results from each tag are tabulated separately (Table 3). The greatest number of fish were recaptured by stake gillnets, however many were also taken by fyke nets, pound nets, and haul seines. The recapture rate by hook and line was higher than for some of the more important commercial gears.

LOCATION OF RECAPTURES

Returns from York River Tagging.— From the 1957 tagging, 142 striped bass (39 percent) were recaptured (Table 4). Of these, 127 (89 percent) were recaptured in the York River system, and 8 (6 percent) were recaptured in Chesapeake Bay or other Bay tributaries (Fig. 2). Six striped bass (4 percent) were recaptured along the Atlantic coast, single recaptures being made at each of the following locations: Indian River, Delaware; Highland and Sandy Hook, New Jersey; Warren and Point Judith, Rhode Island; and Saco, Maine (Fig. 3).

From the 1958 tagging, 276 (27 percent) of the striped bass were recaptured (Table 5). Of the recaptured fish, 248 (90 percent)

TABLE 3.—Number of tagged striped bass, *Roccus saxatilis*, recovered by various gears.

Recovery gear	Tag type			
	Streamer tags		Petersen tags	
	Number recovered	Percent recovered	Number recovered	Percent recovered
Stake gillnet	106	27	177	62
Fyke net	93	24	6	2
Hook and line	53	14	25	8
Haul seine	44	11	23	8
Pound net	33	8	30	11
Drift gillnet	27	7	17	6
Anchor gillnet	9	2	3	1
Oyster dredge	1	—	0	0
Gear unknown	23	6	5	2
Total	389	99	286	100

TABLE 4.—Recapture locations and seasons for striped bass, *Roccus saxatilis*, tagged in the York River during February 1957.

Location of recapture	Season of recapture					
	Winter	Spring	Summer	Fall	Date unknown	Total
York River	44	35	5	2	7	93
Pamunkey River	2	12	—	—	—	14
Mattaponi River	1	8	1	—	—	10
Mobjack Bay	2	4	4	—	—	10
Chesapeake Bay	2	6	—		—	8
Atlantic coastal waters	—	5	—	1	—	6
Location unknown	—	—	—	—	1	1
Total	51	70	10	3	8	142

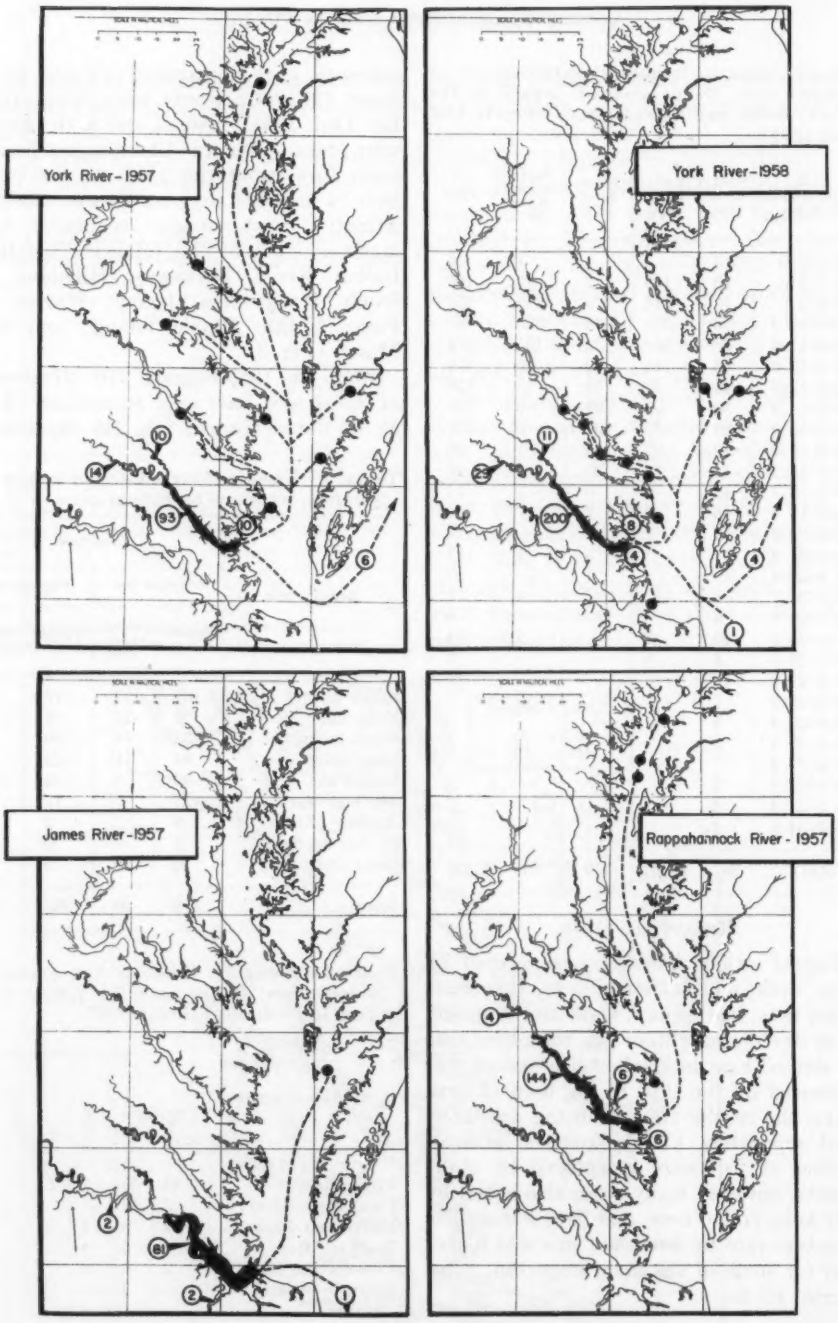

Fig. 2.—Recapture locations of tagged striped bass, *Roccus saxatilis*. The river in which fish were tagged is shown in black, encircled numbers denote number of recaptures and black dots indicate a single recapture. The dotted lines indicate possible migration routes.

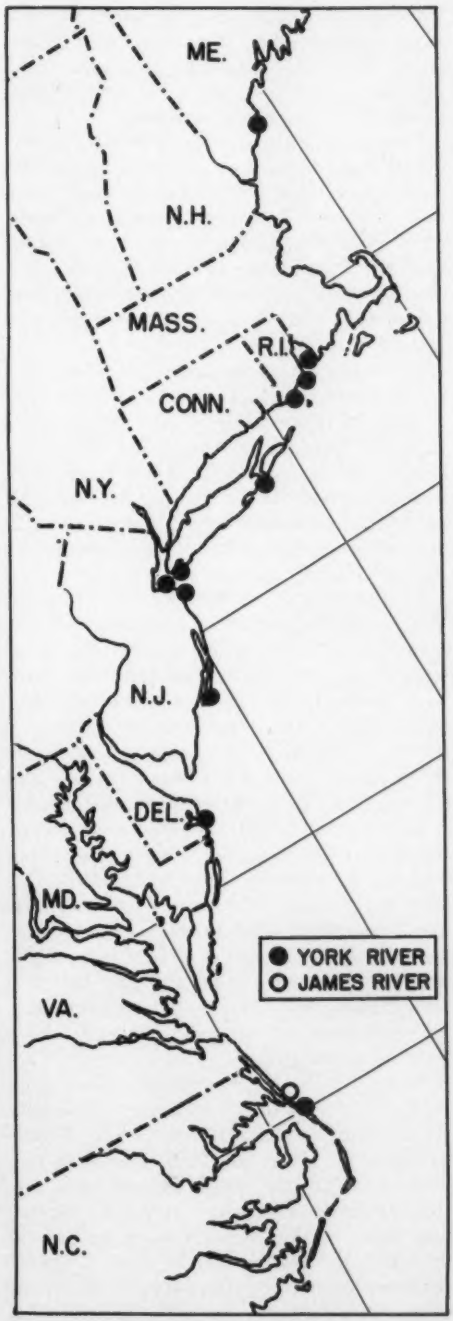

Fig. 3.—Locations along the Atlantic coast at which striped bass, *Roccus saxatilis*, tagged in Virginia waters of Chesapeake Bay were recaptured.

TABLE 5.—Recapture locations and seasons for striped bass, *Roccus saxatilis*, tagged in the York River during February 1958.

Location of recapture	Season of recapture					
	Winter	Spring	Summer	Fall	Date unknown	Total
York River	68	81	17	16	18	200
Pamunkey River	2	23	3	1	—	29
Mattaponi River	2	8	1		—	11
Mobjack Bay	—	6	1	1	—	8
Chesapeake Bay	—	9	2	1	1	13
Atlantic coastal waters	—	3	1	1	—	5
Location unknown	1	3	—		6	10
Total	73	133	25	20	25	276

were taken in the York River system, and 13 (5 percent) from the Piankatank and Rappahannock Rivers or other areas of Chesapeake Bay (Fig. 2). Five fish (2 percent) were recaptured along the Atlantic coast; one each at the following locations: near Nags Head, North Carolina; Shrewsbury River, New Jersey; Jamaica and Moriches Bays, New York; and Point Judith, Rhode Island (Fig. 3).

Returns from James River Tagging.—Of the striped bass tagged in the James River, 93 (22 percent) were recaptured (Table 6). Ninety-one of those recaptured (98 percent) were taken in the James River system, one was recaptured in Chesapeake Bay (Fig. 2) and one was taken in the Atlantic Ocean near Kitty Hawk, North Carolina (Fig. 3).

Returns from Rappahannock River Tagging.—Of the striped bass tagged in the Rappahannock River, 164 (26 percent) were recaptured (Table 7); of these, 160 (98 percent) were taken in the Rappahannock River system and 4 (2 percent) were recovered in other parts of Chesapeake Bay (Fig. 2).

SEASON OF RECAPTURE

To determine seasonal movements within river systems as well as outside of them,

TABLE 6.—Recapture locations and seasons of striped bass, *Roccus saxatilis*, tagged in the James River during March 1957.

Location of recapture	Season of recapture				
	Winter	Spring	Summer	Fall	Total
James River	45	37	2	3	87
Upper James River	—	1	—	1	2
Nansemond River	1	1	—	—	2
Chesapeake Bay	—	1	—	—	1
Atlantic coastal waters	—	1	—	—	1
Total	46	41	2	4	93

TABLE 7.—Recapture locations and seasons of striped bass, *Roccus saxatilis*, tagged in the Rappahannock River during April 1957.

Location of recapture	Season of recapture				
	Spring	Summer	Fall	Date unknown	Total
Rappahannock River	127	9	5	3	144
Upper Rappahannock River	4	—	—	—	4
Corrotoman River	6	—	—	—	6
Piankatank River	6	—	—	—	6
Chesapeake Bay	1	2	1	—	4
Total	144	11	6	3	164

recapture data were summarized for winter, spring, summer, and fall (Tables 4–7). Since many tags were returned with only the month but not the day they were recaptured, the seasons were arbitrarily defined as: winter, January 1 to March 31; spring, April 1 to June 30; summer, July 1 to September 30; and fall, October 1 to December 31.

In winter, the season when most tagging was done, 169 tags were returned with information on the date and location of recapture. Little movement was indicated since 93 percent of the fish were recaptured in the same river, and often near the location of tagging. Four percent of the fish were captured in freshwater areas, upriver from tagging sites, 2 percent were taken from tributaries or bays near the river mouths and 1 percent were from Chesapeake Bay or Atlantic waters.

In spring 384 recaptures indicated a dispersal from tagging areas. Only 73 percent were taken from the river in which they were tagged, 15 percent were from freshwater spawning areas upriver, 6 percent were from tributaries or bays near the river mouths and 6 percent were recaptured from Chesapeake Bay and Atlantic coastal waters.

In summer the 48 tag recaptures indicated that fish had become widely dispersed. In this season 70 percent were recaptured from the river in which they were tagged, 10 percent were taken from fresh waters upriver, 10 percent were from bays or tributaries near the river mouths and 10 percent were recaptured from Chesapeake Bay or Atlantic coastal waters.

In fall 33 tagged fish were recaptured. Tag recoveries suggested that fish were returning to the river in which they were tagged, for 79 percent of the recaptures were made there. Six percent of the fish were taken from fresh waters upriver, 3 percent from bays or tributaries near the river mouth and 12 percent were from Chesapeake Bay or Atlantic coastal waters.

Most of the tagged fish that were recaptured were taken within a year after being tagged, however 68 were recaptured more than one year, 4 were recaptured two years, and 1 was recaptured three years after tagging. With the exception of four fish caught in late spring (two from the Bay and two from coastal waters of the Atlantic Ocean), all were taken in the same river in which they were tagged.

More than half of the striped bass tagged in the York, James, and Rappahannock Rivers were less than 12 inches long (Table 2). Most of these fish were less than two years old. Of the 1378 striped bass less than 12 inches long when they were tagged, only 3 were taken outside the river system in which they were tagged. Two were recaptured in Chesapeake Bay and 1 was taken from Atlantic coastal waters. On the other hand, of 1048 striped bass from 12 to

35-inches long when tagged, 38 were recaptured in waters outside the river system in which they were tagged.

Discussion and Conclusions

Ninety-four percent of all striped bass recaptured were taken from the river system in which they were tagged. This strong tendency to remain isolated in a single river system, at least at the smaller sizes, is evidence to support the conclusions of Raney (1957) that distinct subpopulations of striped bass are present in Chesapeake Bay. Fish from the James River showed a greater tendency to remain in their home river than did those from the York and Rappahannock rivers. This finding supports the results of Vladykov and Wallace (1938 and 1952) who found that James River fish tend to be a static population. The James River subpopulation (Raney, 1957) differed most from those of the York and Rappahannock Rivers and upper Chesapeake Bay.

Six percent of the striped bass were recaptured outside of the river system where they were tagged. Striped bass tagged in the York River were taken in other areas more frequently than those tagged in the James or Rappahannock Rivers. Recoveries from the York River suggested that some fish moved south from the York River mouth. None, however, were recaptured from the James River. A number of York River fish moved north from the river mouth. Some of these entered the Rappahannock River, and the rest scattered in the upper Bay. A third group moved across the Bay as indicated from recaptures in Tangier and Pocomoke Sounds. A fourth group left the Bay and, with one exception, moved north along the Atlantic coast to middle Atlantic and New England waters.

From the James River tagging only two fish were recaptured in waters outside the James River system. Recoveries from striped bass tagged in the Rappahannock River suggested that most of the fish which left the Rappahannock River system moved north to the upper part of Chesapeake Bay.

Since striped bass more than 12 inches in length moved more extensively than those less than 12 inches, the larger York River fish were expected to move more extensively than the smaller fish tagged in the Rappahannock River. The intermediate sized fish tagged in the James River moved least.

Although most striped bass remained in or near the river system where they were tagged, seasonal movements were indicated. In winter, most fish were recaptured not far from where they were tagged. In spring, although many fish were recaptured near the tagging areas, larger numbers were recaptured in upriver spawning areas and some had moved into the Bay and even to Atlantic waters. Summer recoveries suggested that striped bass scattered widely. Although many were recaptured in the river where they were tagged, more were taken in Chesapeake Bay and Atlantic waters than during any other season. In fall most striped bass were recaptured from the river in which they were tagged. An interesting exception was a fish recaptured from Moriches Bay, New York, in December. Seasonal movements closely approximated those observed for striped bass in California waters (Calhoun, 1952).

Merriman (1941) found little evidence that striped bass younger than two years old undertook coastal migrations. The results of this tagging program suggested that striped bass from 7 to 12 inches long remained in a single river system, while fish over 12 inches in length moved into Chesapeake Bay or along the Atlantic coast. Chapoton and Sykes (1961) indicated the extent of coastwide migrations by large striped bass.

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Trichomonad Infection in Mourning Doves, *Zenaidura macroura*, in Maryland

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ABSTRACT

During the 10-year period 1950–1960 the incidence of *Trichomonas gallinae* among several series of mourning doves shot or trapped in Maryland has varied from zero to 12½ per cent. Prior to 1959, all isolations of *T. gallinae* from doves during such surveys had been from birds with well-developed lesions. In 1959, trichomonads were demonstrated in three of 54 normal hunter-killed doves examined in Howard County.

The incidence of trichomonad infection among doves which were submitted to the laboratory because they were obviously diseased was much higher. Of 44 clinically ill doves submitted during the period 1950–1960, 25 were found to be infected with *T. gallinae*.

In the Maryland area the incidence of trichomonad infection among mourning doves appears to be low, but when infection does occur it is usually due to a pathogenic strain which produces a typical fatal canker.

Trichomonas gallinae (Rivolta) was first reported from mourning doves, *Zenaidura macroura* (L.), by Cauthen (1934:22). Since then, this pathogenic protozoan has been found in mourning doves throughout North America (Stabler and Herman, 1951:145–63). In 1950, a severe epizootic in Alabama focused attention upon the disease as a major cause of dove mortality (Haugen, 1952:164–9; Haugen and Keeler, 1952:141–51).

During the decade of 1950–1960, studies on *T. gallinae* have been conducted by various members of the staff of the disease laboratory of the Patuxent Wildlife Research Center. This paper reports the findings on the incidence of trichomonad infection among Maryland doves during this period.

Materials and Methods

A total of 578 mourning doves were examined during this period. Approximately half, 285, were trapped on the Patuxent Research Center for banding. These birds were examined for trichomoniasis, and, if found to be free of infection, were banded and released. Forty-one doves examined in 1953 and 194 doves examined in 1959 and 1960 were hunter-killed birds examined shortly after they had been shot. An additional 44 doves examined were individual birds found sick or injured and submitted to the laboratory. Fourteen nestling mourning doves were examined 1959–1960.

The doves were examined by obtaining microscopic smears of dove saliva or by inoculating dove saliva onto ovo-mucoid culture medium (in 1950–51), LBSS medium (1951–1957, part of 1960), or Diamond's trichomonad medium (1958–1960), and then incubating at 37.5° C overnight. The medium was examined for trichomonads the following day. Diamond's medium (Diamond, 1957:488–90) was the most satisfactory, although LBSS (Rakoff, 1934: 502–13) was used frequently.

Results and Discussion

The results of the examination of doves trapped for banding or killed by hunters are summarized in Table 1.

The incidence of *Trichomonas gallinae*, as shown in Table 1, has varied from zero to 12½%. Prior to our isolation of *T. gallinae* from 3 of 54 hunter-killed doves in 1959, all our isolations had been from doves with recognizable lesions of trichomoniasis. Herman (unpublished data) found no *T. gallinae* in 72 Ohio doves examined in 1951–52 and none in a series of 90 doves from Georgia examined in 1951. Among

TABLE 1.—*Trichomonas gallinae* infection in mourning doves, *Zenaidura macroura*, trapped or shot in Maryland.

Location[1]	Examined[2] By	Collection Method	Date	Number of Samples	Lesions	*T. gallinae* Found
P.R.R.	C.M.H.	Trapped	8/1–12/15/50	32	1	1
P.R.R.	C.M.H.	Trapped	2/9–3/23/51	74	0	0
P.R.R.	L.S.D.	Trapped	8/7/51–6/24/52	31	1	1
P.R.R.	C.M.H.	Shot	10/22–29/53	41	0	0
P.R.R.	L.N.L.	Trapped	5/58–9/58	41	1	1
A.R.C.	L.N.L.	Trapped	9/58	24	0	0
P.R.R.	L.N.L.	Trapped	10/58–10/59	43	2	2
Howard Co.	L.N.L.	Shot	9/59	54	0	3
P.W.R.C.	L.N.L.	Trapped	10/59–10/60	40	5	5
Howard Co.	L.N.L.	Shot	9/60	140	0	0

[1] P.W.R.C.: Patuxent Wildlife Research Center (Patuxent Research Refuge before 1959).
A.R.C.: Agricultural Research Center.
[2] C.M.H.: Carlton M. Herman, U. S. Fish and Wildlife Service.
L.S.D.: Louis S. Diamond, formerly U. S. Fish and Wildlife Service, now with National Institutes of Health.
L.N.L.: Louis N. Locke, U. S. Fish and Wildlife Service.

pigeons, the incidence of the disease is higher and a greater proportion show lesions. Our examination of 148 locally obtained pigeons showed 109 positive for *Trichomonas*, 8 with lesions. Stabler (1951: 473–4) examined 100 mourning doves collected in Colorado in 1948, 1949, and 1950, and found 23 positive. Some of his doves showed loss of palatal tissue, and one juvenile was dying with extensive oral lesions.

The large series of 140 hunter-killed mourning doves from Howard County, Maryland (Table 1), were collected within a 6-mile radius of a banding station maintained by Dr. Aelred D. Geis, U. S. Fish and Wildlife Service, near Clarksville, Maryland. During the period between April 19 and September 5, 1960, a total of 365 doves were banded at this station. Despite the fact that no trichomonads were found in the series of hunter-killed doves near this station, trichomoniasis was known to have occurred at this banding station in August and September, 1960. Trichomonad infection was demonstrated in two doves collected on August 31 and September 3. Birds with typical trichomonad lesions were seen on June 22 and August 21, but these were not examined microscopically (A. D. Geis, personal communication, 1960).

Each year several mourning doves (not included in Table 1) were found sick and submitted to the laboratory for necropsy. A much higher incidence of trichomonad infection was found among these birds than among the trapped and shot birds. Results of our examinations of doves submitted between May 1, 1959 and October 1, 1960 are shown in Table 2. Most of the sick doves were obtained and submitted by enforcement personnel of the Maryland Department of Game and Inland Fish. Several infected doves were collected at backyard bird-feeding stations in the Washington metropolitan area (Washington, D. C.; Takoma Park, Maryland; and, Arlington, Virginia). Mourning doves concentrate around these backyard feeders and sick birds are frequently seen. These sick birds can transmit infection to other birds visiting the feeding area, so that the area becomes an enzootic focus of infection. Rosen (1959:12–3) found that such backyard feeding establishments were of major importance in maintaining trichomonad epizootics in San Diego, California. Backyard die-offs also have occurred in Atlanta, Georgia, and St. Louis, Missouri.

During the spring of 1959 (April 11–May 13), a series of six throat swabbings was obtained from dove nestlings on the Patuxent Research Center and six from an area near Mitchellville, Maryland.

Three of the nestlings were found dead, but neither they nor the nine living nestlings had trichomonad cankers, and all attempts to demonstrate *Trichomonas gallinae* by culture failed. On July 13, 1960, two nestlings from a nest located in shrubbery near the bird-banding office on the Patuxent Research Center were examined and found to have caseous lesions in the mouth; *T. gallinae* was cultured from both. These were the only isolations of *T. gallinae* from mourning dove nestlings found on the Center during the period 1950–1960. Trichomonad infections frequently occur in nestling doves, however. Locke (unpublished data) found 53 of 101 mourning dove nestlings collected in Texas in July, 1960, to be infected with *T. gallinae*. Some of the infected birds were only 2–3 days old. None of the nestlings exhibited caseous lesions or signs of loss of palatal fringe.

Harwood (1946:57–8) reported the first fatal case of *T. gallinae* in a nestling mourning dove in a bird collected near Ashland, Ohio. Herman and Burgee (1956, unpublished data) conducted a survey of *Trichomonas* infection in nestling mourning doves by mailing tubes of culture medium to cooperators in several states. Of 444 tubes mailed, 177 were returned, and 4 of these were found to contain *T. gallinae*. Three of the positive isolates came from Kentucky and the fourth from Tennessee. No *T. gallinae* was found in culture tubes returned from Alabama, Minnesota, or Mississippi. Sprunt (1957) found that in 15 of 23 nests the full clutch of two young was not fledged. In five nests, the birds died after hatching. In three of these, the young birds developed trichomoniasis and five of the six died. *T. gallinae* was first noted in smears of saliva when a nestling was 4 or 5 days old. Lesions appeared on the sixth day and deaths usually occurred 8 days after hatching. One nestling, which recovered from the infection, was moved to the laboratory on the 9th day and killed for autopsy on the 14th day after hatching. Although *T. gallinae* had been demonstrated in esophageal smears throughout this period, no lesions were found at autopsy.

One of the major questions yet to be answered is the effect of trichomoniasis upon mourning-dove productivity. In those areas where continuing losses due to *T. gallinae* have been reported, studies should be conducted to determine what percentage of the year's production of young die from the infection.

TABLE 2.—Sick mourning doves submitted to Patuxent Wildlife Research Center for necropsy, 1959–1960.

Locality	Date	Findings
Takoma Park	5/25/59	Bacterial enteritis
Takoma Park	6/25/59	Trichomoniasis
Anne Arundel County (cornfield)	7/1/59	Trichomoniasis
Wheaton	7/11/59	Small necrotic areas in mouth, *T. gallinae* not demonstrated
University Park	7/20/59	Trauma
Anne Arundel County (Navy Dairy Farm)	8/11/59	No *T. gallinae*; cause of death unknown
Clarksville	9/22/59	No *T. gallinae*; hit by car
Agr. Res. Center (granary)	9/25/59	Trichomoniasis
Laurel-Bowie Road (adjacent to P.W. R.C.)	7/1/60	Trichomoniasis; trauma
Laurel-Bowie Road (adjacent to P.W.R.C.)	7/6/60	Trauma; no *T. gallinae*
Anne Arundel County	7/12/60	Trichomoniasis
Clarksville	8/31/60	Trichomoniasis

Conclusions

During the period 1950–1960, the incidence of *Trichomonas gallinae* shown in several surveys of doves trapped or shot in Maryland varied from zero to 12.5%. In this same period, 44 clinically ill doves were submitted to our laboratory, and *T. gallinae* was isolated from 25 of these.

Fourteen nestlings were examined and two were infected. Both of these had well developed lesions.

Although the incidence of trichomonad infection among mourning doves in Maryland appears to be low, when infection does occur it is usually caused by highly virulent strains which produce fatal infections.

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Investigations of Inner Continental Shelf Waters Off Lower Chesapeake Bay. Part II. Sand Lance Larvae, *Ammodytes americanus*[1]

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ABSTRACT

Plankton samples were collected monthly from 22 stations in the Atlantic Ocean and 3 in Chesapeake Bay. Numerous larvae of sand lance, *Ammodytes americanus*, were taken from January through April, 1960. Larvae were widely distributed over the survey area but were most abundant beyond 25 miles from shore.

Statistical analysis of sample mean lengths indicated movement offshore and a tendency for a group hatched together to remain together.

Rate of larval development was approximated at 11.7 mm per month for the first four months. It is believed that spawning occurred at 5–12 fathoms in the study area. Hatching began in late November, reached a peak sometime after mid-December, and continued until mid-March.

Few larvae were collected in waters with salinities less than 30‰.

Introduction

In December 1959, the Virginia Fisheries Laboratory began a monthly series of collecting cruises in lower Chesapeake Bay and adjacent waters of the Atlantic. The main purpose of this program was to obtain information about the distribution of pelagic fish eggs and larvae. A detailed description of the study area, materials, and methods is provided by Joseph, et al., (1960).

The most abundant fish collected in the early cruises was the American sand lance or sand eel, *Ammodytes americanus* Dekay. Over 3500 larvae were taken between January and May 1960.

The American sand lance has often been captured on plankton surveys in Atlantic coastal waters but its life history is poorly documented. Because of the numbers obtained during the present survey and their wide distribution in time and space, additional information on the early life history of this fish is now available.

There are several species of European sand eels but the relationship of *A. americanus* to the European forms has not been fully established. Bigelow and Schroeder (1953:488) stated that the European *A. tobianus* Linnaeus is closely related to *A. americanus* and indicate doubt that these two populations will stand as distinct species. There has been considerable confusion regarding the systematics of the species of European sand eels. Einarsson (1955:6) following Jensen (1941) used Cuvier's name *A. lancea* replacing *A. tobianus* because it was felt that several species had been included under *A. tobianus*. Backus (1957:307) reviewed Jensen's work and concluded that the name *tobianus* be retained. More recently, Cameron (1959:17) also employed *A. tobianus* as a full species synonymous to *A. lancea*. Andriiashev (1954:317) gave *A. tobianus* full species recognition in the same sense as Backus (1957) and Cameron (1959) but was not cited by either. A thorough investigation of the larval, post-larval, and adult characteristics of *A. americanus* and *A. tobianus* is needed to establish definitely the relationship between these closely allied American and European forms.

The sand lance is distributed along the

[1] Contribution No. 96, Virginia Fisheries Laboratory, Gloucester Point, Virginia.

Atlantic Coast from northern Labrador to Cape Hatteras according to Jordan and Evermann (1896:833), Sumner, et al. (1913:748), Dannevig (1919:29), Huntsman (1922:62), Fish and Johnson (1937: 258), and Wheatland (1956:277). It is most abundant along sandy shores and seldom seen off rocky coasts. South of Cape Cod it is found along the inner portion of the continental shelf (Wheatland).

The sand lance is a small slender fish; the adults average 4–6 inches in length with a few individuals reaching 7 inches (Bigelow and Schroeder, 1953:488). It is a schooling fish frequently forming great shoals. In the summer during high tide, sand lances often swarm onto sandy beaches above the low-water mark where they burrow into the sand and reappear with the next high tide (Jordan and Evermann, 1896:833; Bigelow and Schroeder).

The stages of larval development have not been described in detail. Bigelow and Schroeder (1953:490) and Wheatland (1956:279) briefly described some of the stages. Wheatland captured larvae 3.1 mm (with yolk sac) to 33.5 mm with fins almost completely differentiated. Bigelow and Schroeder stated the larvae to be about 7 mm in length before the yolk sac is absorbed and that dorsal and anal fin rays are visible at 18 mm.

Several stages of development are illustrated in Fig. 1 and some of the salient features of larval growth may be noted. At very early stages and throughout the period of development the sand lance is very slender. The vent opens to one side, not at the margin of the fin fold. The lower jaw is protrusible even in very early stages and with development, the head assumes the characteristic pointed appearance of the adult. The melanophore pattern is pronounced in early stages and consists of a row of pigmented cells dorsal to the intestine which shows internal folds at about 8 mm. Beginnings of the caudal rays may be seen at 8 mm and anal and dorsal fin rays appear at 13 mm. By the time the larvae are about 15 mm long, the caudal rays are developed but the tail is not forked until about 22 mm.

Though of no direct commercial importance in this country at this time, sand lances do play an important role in the economy of northern seas by providing food for such fishes as cod, halibut, haddock, silver hake, salmon, mackerel, striped bass, and bluefish (Bigelow and Schroeder, 1953: 489), and white marlin (Wallace and Wallace, 1942:7). Einarsson (1951:5) pointed out that, "Areas where these fishes are abundant are extremely fertile fishing grounds and owe their fertility in a high degree to the presence of shoals of these fishes."

An interesting point has been brought to our attention in connection with the relationship of the flounders, *Paralichthys dentatus*, and sand lances. Trawler captains have come to rely heavily on echo traces of fish finders to locate fish. Since flounders are bottom fishes, their presence cannot be detected by echo sounding. However, many fishermen now recognize certain echo traces which they believe are made by sand lances. Whenever such traces are observed, a drag often results in catches of flounder which have fed on sand lances.

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Materials and Methods

Twenty-two Atlantic and three lower Chesapeake Bay stations were sampled monthly. The Chesapeake Bay stations are located at 10-mile intervals beginning near the mouth of the Bay and terminating at the mouth of the York River. The oceanic stations, arranged in a grid pattern of 10-mile intervals, are aligned in east-west transects and north-south columns. Transects take their designation from the latitude and columns are numbered from I to IV beginning near shore and proceeding seaward. Because of the land configuration north and south of the Bay entrance, col-

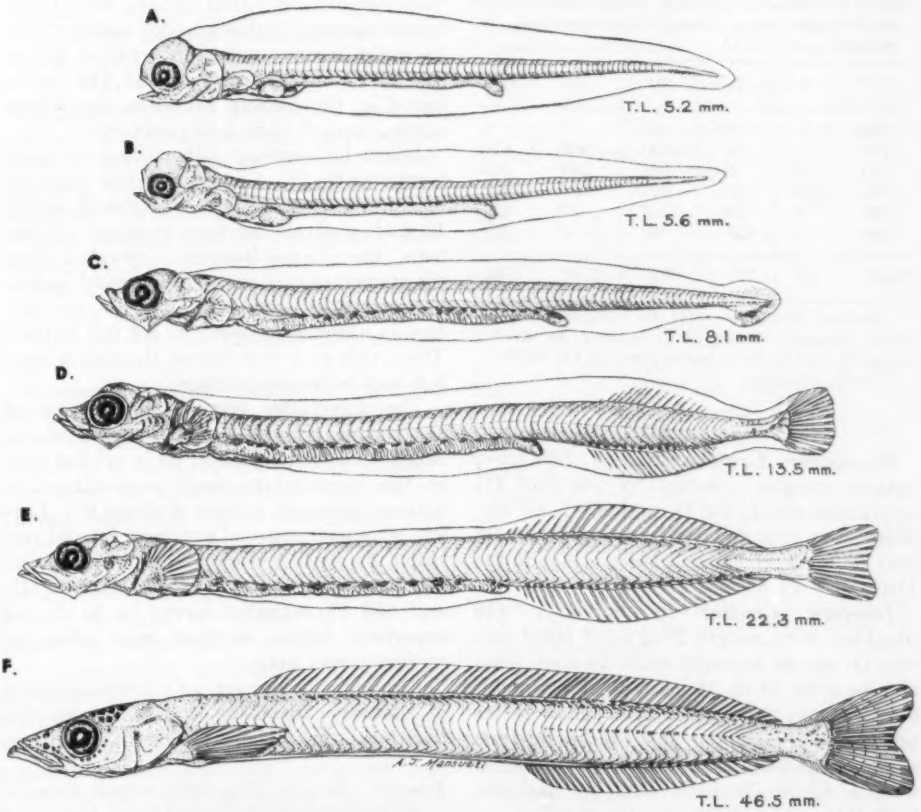

Fig. 1.—Larvae and young of the sand lance, *Ammodytes americanus*, collected in the Atlantic Ocean off the mouth of Chesapeake Bay.

A. Prolarvae; 5.2 mm T.L.; Myotomes (preanal and postanal = total number) 40 + 25 = 65; B. Prolarvae; 5.6 mm T.L.; Myotomes 41 + 26 = 67; C. Postlarvae; 8.1 mm T.L.; Myotomes 43 + 25 = 68; D. Transforming postlarvae; 12.8 mm S.L.; Myotomes 40 + 24 = 64; E. Early young; 20.5 mm S.L.; Myotomes 39 + 22+ = 61+; F. Young; 42.6 mm S.L.; Myotomes 36 + 25+ = 61+. [T.L. = Total Length; S.L. = Standard Length]

umns vary in distance from land, in fact, Column I has but one station north of the Bay. The offshore station pattern is shown in Fig. 3.

Generally, sampling consisted of surface tows with paired meter or ½-meter nets, Clarke-Bumpus surface and bottom tows, and a Gulf III bottom tow during daylight hours. As expected, there were deviations from the general sampling routine. Specific gear use by month and station is available in summary form (Norcross, et al., 1961).

Once begun, sampling continued until completion of the cruise, weather permitting. Such an operation called for day and night sampling. In some circumstances it would have been desirable to repeat sampling on some stations. For instance, having found concentrations of larvae in either surface or bottom waters during the day, a repeat sampling on that same station at night would have permitted a more accurate evaluation of the diel change in vertical distribution of the larvae.

TABLE 1.—January—Station distribution of larvae of sand lance, *Ammodytes americanus*, all samples combined.[1]

	I	II	III	IV	Total
730	x	0	0	6	6
720	x	0	174	802	976
710	2	5	2[2]	348	357
700	25	9	17	976	1027
650	0	28[2]	114[2]	27[2]	169
640	0	135	90	2[2]	227
Total	27	177	397	2161	2762

[1] Roman numerals refer to column designations; transect designations appear as Arabic numerals on the left hand column of the table.
[2] Night sampling.

SAMPLING RESULTS

December Cruise:—Except for three bottom samples collected by the Gulf III at stations 640 I, 640 II, and 650 I, all stations were sampled by two surface meter nets. There were no sand lance larvae in the December collections.

January Cruise:—In January, 119 plankton tows caught 2762 sand lance larvae. Of the 86 daylight hauls 24 were positive as were 14 of 33 hauls made at night. Surface tows were made with paired meter or ½-meter nets and the Clarke-Bumpus sampler. Bottom samples were obtained with a Clarke-Bumpus sampler and the Gulf III (used only during the day).

Sand lance larvae were widely distributed over the survey area (Table 1). Numbers of larvae increased seaward through Column IV. The seaward extent and peak of larval distribution remain unknown.

The greatest numbers of young sand lances were captured on stations 720 III, 720 IV, 710 IV, and 700 IV. Beginning at 0930 hours on January 24, 1960 and continuing to 1640 hours, these stations were sampled in the same sequence as noted above. Weather and sea conditions were excellent—no cloud cover, light winds, and slight swells. Gear used included paired ½-meter nets of Marion Mesh towed on the surface, two Clarke-Bumpus samplers with #2 mesh (one towed near the surface, the other close to the bottom), and the bottom Gulf III.

Of the 2300 larvae caught on these stations, 93 percent (2149 larvae) were taken by the surface Clarke-Bumpus sampler. The ½-meter surface nets captured no larvae and undoubtedly many of the 145 larvae found in the bottom samplers came from surface waters upon gear recovery.

It was by accident that we took so many larvae with the Clarke-Bumpus sampler. Ordinarily the sampler was fished within 18 inches of the surface, however at this time, the Clarke-Bumpus (operated from the starboard side of the *Pathfinder*) had to be lowered at least 4–5 feet below the surface in order to compensate for roll to port. Thus, this gear was towed through a zone 3–8 feet below the surface.

The day-night vertical distribution of the various size classes represented in the catch is shown in Table 2. It is evident that at this time larvae were predominant in surface layers by a ratio of about 6:1. Larvae were concentrated in a zone several feet below the surface during daylight hours but night sampling on stations 650 II, 650 III, and 650 IV revealed larvae to be in the superficial layers, as most were taken by surface meter nets.

Although 85 percent of larvae collected in January came from surface waters, this does not indicate a specific depth preference

TABLE 2.—January—Day-night vertical distribution by size classes of the sand lance, *Ammodytes americanus*.

	Size classes (mm)			
	5–9	10–14	15–19	Total
Surface				
Day	649	1448	101	2198
Night	146	12	0	158
Total	795	1460	101	2356
Bottom				
Day	217	154	11	382
Night	2	2	0	4
Total	219	156	11	386
Grand total				2742[1]

[1] This figure does not include 20 un-measurable larvae.

by young sand lances, for this vertical distribution was not consistent on every station. Gulf III samples taken on stations 640 II and 640 III in the daytime clearly showed larvae to be distributed near the bottom. The bottom sampler caught eight times as many larvae as did the surface samplers. Many more larvae were captured during the day than at night; however, we sampled areas of high concentrations during the day.

Three size groups were collected in January with the 10–14 mm group dominant and the 5–9 mm size group next in importance.

February Cruise:—Sampling effort in February consisted of 74 day tows (26 positive) and 28 night tows (18 positive) resulting in a catch of 211 larvae, a sharp drop from the numbers taken in January. Larvae were distributed throughout the survey area, but were poorly represented on Column I (Table 3). The largest sample contained only 20 specimens. Numbers increased seaward to Column III but decreased on Column IV.

The day-night bathymetric distribution is shown in Table 4. Larvae probably were distributed throughout the water column at this time. Two additional size classes appeared in February. The dominant size group of the previous month was poorly represented. Judging from estimated larval growth (discussed below) the 15–19 mm and 20–24 mm size groups should have been well represented in February.

March Cruise:—In March a total of 135 tows was made. Day effort amounted to 107 tows (24 positive); 28 night tows were made (14 positive).

A total of 550 sand lance larvae was taken from Atlantic stations. In addition, two larvae were taken from bottom waters at station CB-O, located just inside the mouth of Chesapeake Bay. Larvae were widely distributed over the sampling area (Table 5) as indicated by captures on all but two stations. Greater numbers appeared on the onshore stations than in any preceding months. Again the catch on Column IV exceeded other column totals.

Some interesting changes in the March

TABLE 3.—February—Station distribution of the larvae of the sand lance, *Ammodytes americanus*, all samples combined.

	I	II	III	IV	Total
730	x	3	4	11	18
720	x	0	2	10	12
710	1[1]	5[1]	18[1]	11[1]	35
700	0	20[1]	16[1]	13[1]	49
650	0	11	37	20	68
640	0	4	19	6	29
Total	1	43	96	71	211

[1] Night sampling.

TABLE 4.—February—Day-night vertical distribution by size classes of the sand lance, *Ammodytes americanus*.

	Size classes (mm)					
	5–9	10–14	15–19	20–24	25–29	Total
Surface						
Day	8	24	0	1		33
Night	8	27	7	2		44
Total	16	51	7	3		77
Bottom						
Day	17	45	12	4	1	79
Night	12	16	3	5	0	36
Total	29	61	15	9	1	115
Grand total						192[1]

[1] This figure does not include 19 un-measurable larvae.

TABLE 5.—March—Station distribution of larvae of sand lance, *Ammodytes americanus*, all samples combined.

	I	II	III	IV	Total
730	x	4	6	30	40
720	x	1	5	9	15
710	18	29[1]	7[1]	92[1]	146
700	0	91[1]	93[1]	32[1]	216
650	13	8	2	6	29
640	94	9	0	1	104
Total	125	142	113	170	552[2]

[1] Night sampling.

[2] Including two specimens from station CB-O.

sampling results with respect to size class representation and vertical distribution (Table 6) are noteworthy. March samples contained specimens which ranged in size from 5 to 48 mm. The 10–14 mm size class again contained the greatest number of larvae with the 5–9 mm class next in importance. Over 93 percent of larvae in these size classes were taken from bottom waters. This is almost a complete reversal from January observations when 86 percent of the larvae in the same size range were obtained from surface waters. Persistent northeast winds of 10–18 knots created moderate to rough sea conditions. This may have accounted for the observed difference in vertical distribution.

TABLE 6.—March—Day-night vertical distribution by size classes of the sand lance, *Ammodytes americanus*.

	Size classes (mm)							
	5–9	10–14	15–19	20–24	25–29	30–34	34	Total
Surface								
Day	11	4	0	0	0	0	2	17
Night	10	8	0	5	5	13	25	66
Total	21	12	0	5	5	13	27	83
Bottom								
Day	48	114	2	6	0	0	0	170
Night	93	170	18	7	2	2	5	297
Total	141	284	20	13	2	2	5	467
Grand total								550[1]

[1] This figure does not include two un-measurable larvae.

TABLE 7.—April—Station distribution of the larvae of the sand lance, *Ammodytes americanus*, all samples combined.

	I	II	III	IV	Total
730	x	3	3	0	6
720	x	2	6	2	10
710	0	5	4	1	10
700	8	6[1]	0[1]	1	15
650	28	22[1]	13[1]	1[1]	64
640	32	5	3[1]	13[1]	53
Total	68	43	29	18	158

[1] Night sampling.

TABLE 8.—April—Day-night vertical distribution by size classes of the sand lance, *Ammodytes americanus*.

	Size classes (mm)					
	10–14	15–19	20–24	25–29	30–34	Total
Surface						
Day	10	14	13	2	0	39
Night	9	17	10	2	1	39
Total	19	31	23	4	1	78
Bottom						
Day	19	30	7	0	0	56
Night	9	7	6	0	1	23
	28	37	13	0	1	79
Grand total						157[1]

[1] This figure does not include 1 un-measurable larva.

For the first time, March samples contained specimens 30 mm and over, all but two taken at night.

April Cruise:—A total of 100 tows was made at this time consisting of 71 day hauls (25 positive) and 29 night hauls (15 positive). Larvae, though widely distributed, never appeared in substantial numbers in any of the samples (Table 7). Total captures amounted to 158 specimens, less than 30 percent of the March total. Larval distribution in April showed for the first time a steady decrease in numbers seaward.

The distribution of size classes (Table 8) indicates that larvae were probably distributed through the water column. The 5–9 mm size class was absent for the first time.

May Cruise:—A single larva (30 mm) was taken at night from station 700 III in surface waters.

Discussion

Temperature and Salinity Factors Influencing Distribution

From the pattern of distribution shown in Table 9 it may be seen that, in general,

returns from stations near shore constituted a small percentage of the total catch. Numbers of larvae taken from stations within 20 miles of the shore amounted to little more than 17 percent of the total, while numbers captured within 25 miles of shore increased to but 24.5 percent of the total catch. Waters 20–25 miles from shore are subject to fluctuations in temperature and salinity of greater magnitude than are waters seaward of this zone. Rapid cooling and warming in the fall and spring occurred in this zone but even more pronounced was the monthly change of salinity patterns within the 25-mile zone (Joseph, et al., 1960).

Our data do not show temperature to be an important factor in the distribution of sand lance larvae. Catches began when water temperatures approximated thermal homogeneity (mean surface 7.22°C and mean bottom 7.32°C). Larvae continued to be taken until waters had again warmed to 8°C (mean surface) and 6°C (mean bottom) with resulting thermal stability.

Salinity appears to be a major factor influencing the distribution of sand lance larvae. Less than 2 percent of the total catch was made in waters having salinities lower than 30 ‰. Captures of larvae in March and April showed substantial increases on Columns I and II over that of January and February, however, salinities exceeding 30 ‰ prevailed on these stations at this time.

Wheatland (1956:278) stated that the salinity tolerance of the sand lance is not known but that she found larvae in waters having salinities as low as 24.18 ‰. In this study no larvae were taken from waters having salinities < 26.44 ‰.

Other workers engaged in larval fish studies have informed us that sand lances have been netted in waters having salinities lower than those reported by Wheatland (1956). For instance, Chamberlin (personal communication) making plankton net collections in White Creek, Indian River, Delaware, found larvae in waters having salinities from 4.3 ‰ to < 1.8 ‰. He suggests from observations that as the sand lance grows it becomes less tolerant of low salinity waters. Pacheco (personal communication) continuing the work of Chamberlin at Indian River, Delaware, reports taking larvae from waters having salinities of 18 ‰.

TABLE 9.—Composite catch of the larvae of sand lance, *Ammodytes americanus*, by station for Jan., Feb., March, April.

	I	II	III	IV	Total
730	x	10	13	47	70
720	x	3	187	823	1013
710	21	44	31	452	548
700	33	126	126	1022	1307
650	41	69	166	54	330
640	126	153	112	22	413
Total	221	405	635	2420	3683[1]

[1]Including two specimens from station CB-O.

It is apparent from the results obtained by Chamberlin and Pacheco that the sand lance is tolerant of salinities well below that normally encountered 20 miles within Chesapeake Bay. It is therefore surprising that despite many collections within Chesapeake Bay only two larvae have been taken, both near the mouth of the Bay. Recently Massmann (1960:70) reported the only occurrence of an adult sand lance within Chesapeake Bay.

REPRODUCTION

The American sand lance spawns from Canada to Virginia with spawning restricted to the inner half of the continental shelf. The spawning season over the range must be of long duration. Larval collections by Dannevig (1919:72), Wheatland (1956), Chamberlin and Pacheco (personal communications), and others indicate that hatching commences sometime in November and continues into May, with the hatching season progressively later in the north.

The egg of the American sand lance has never been described nor has spawning activity been observed. Presumably the egg is demersal, as in European species (Ehrenbaum, 1909:297; Hardy, 1959:211). Since no knowledge exists of the rate of embryological development, it is difficult to estimate the onset and cessation of spawning.

Temperature must play an important role in determining onset of spawning. Wheatland (1956:277) quoting Sette (unpubl.) states that spawning does not begin

until bottom temperatures reach 9°C or less. Our findings differ. It does appear, however, that hatching begins when bottom temperatures approach 9°C, but certainly in the survey area spawning must have occurred sometime before bottom temperature reached 9°C.

From available data, a surmise can be made concerning depths at which spawning occurred. We collected 75 percent of the 5–6 mm larvae within 17 miles of the shore from transects 640 through 730. This leads us to believe that spawning occurred in waters of 5–12 fathoms.

Estimates of the onset, peak activity, and duration of hatching in the study area may be calculated from knowing: (1) the date of initial appearance of larvae in the samples, (2) the mean length of larvae in the initial samples, (3) larval growth rate, and (4) the relative numbers of larvae taken from month to month.

It is estimated that hatching began in late November, 1959, reached a peak shortly after mid-December, and continued until mid-March, 1960. Hatching periods uudoubtedly vary from year to year. In fact, lengths of larvae collected December 15, 1960 indicate that hatching began near the end of the first week in December.

Larval Growth

The range in lengths and the monthly mean of sand lance larvae (Table 10) show increases from January through April but these gains do not represent the average monthly increment of the larvae. It is apparent that there was very little carryover of individuals that comprised the dominant size class of the preceding month. The class interval 10–14 mm contained the greatest percentage of individuals for January, February, and March (Fig. 2) but in April

Table 10.—Monthly mean lengths and size ranges of the larvae of sand lance, *Ammodytes americanus*.

Month	Mean length (mm)	Size range (mm)
Jan.	11.5	5–20
Feb.	12.4	5–27
Mar.	12.8	5–48
Apr.	17.0	10–30

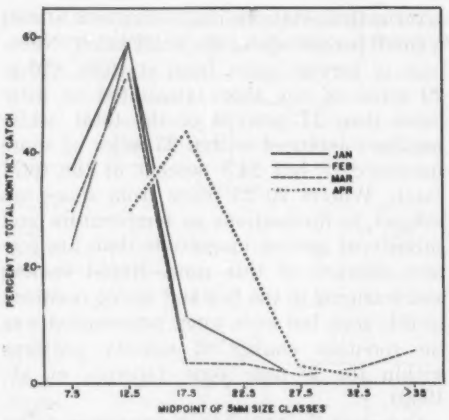

Fig. 2.—Length frequency distribution of larvae of the sand lance, *Ammodytes americanus*, taken offshore from lower Chesapeake Bay.

there was a shift in the mode to the 15–19 mm size class. Wheatland (1956:279) found that 1953–54 samples taken during the winter and spring months showed gains of 3–5 mm per month. In this study, however, only between March and April was a gain of over 3 mm observed. The failure of substantial numbers of larger individuals to appear in samples on cruises after January may be accounted for by high natural mortality, by net avoidance, or by emigration.

Despite the fact that several factors or a combination of factors prevented us from collecting each month a cross-section of the various size groups that may have been present in the population, we do have evidence from one sample which permits an estimate of the average monthly growth rate of sand lance larvae. A sample of 34 specimens was collected in a ½-meter net on station 710 IV on the night of March 16, 1960. These larvae ranged in length from 21 to 47 mm. The sample mean was 34.9 mm with an associated variation of 5.8 mm. About 60 days had elapsed since the January cruise date. Comparing the January mean with the mean of the March 16 sample, we find an average increase of 23.4 mm for 60 days, or about 11.7 mm per month. This value seems to be a more reasonable approximation of the actual monthly growth rate (at least for early stages) than

that indicated by increases in monthly cruise means. It must be remembered that the estimated average increase of about 11.7 mm per month is only an estimate for this period. Water temperatures and other factors undoubtedly influence the growth rate, as Wheatland (1956:279) has suggested.

Masterman (1895:287) estimating larval growth for the lesser sand-eel (*A. tobianus*) states the larvae to be about 10 mm in length by the end of April, 17–18 mm by the third week in May, and about 30 mm in length by the second week in June. Thus in a 6 weeks period the lesser sand-eel grows about 20 mm which is a slightly higher growth estimate than that for the sand lance as stated above.

Size Distribution and Larval Movement

Statistical analyses were made of samples to provide a basis for inference concerning larval dispersal. Changes in distribution within the study area from month to month reveal little about the movement of larvae. The size class composition of the catch (Fig. 2) remained relatively unchanged from January through March. Larvae of 10–14 mm dominated the January catch and amounted to 44 percent of the composite catch, yet these same larvae did not appear in relatively large numbers in the following months. Had these same larvae been present in the survey area throughout the period of collection, their presence would have been indicated by a mode shifting to larger size classes with the passage of time.

It has been pointed out that several factors may be operating to account for failure to collect substantial numbers of large larvae after January. Studies have shown that net avoidance is a problem of great concern in quantitative sampling. Bridger (1956) made day-night comparisons with several types of collecting gear and noted that larger numbers and larger fish larvae were consistently collected at night. He attributed day-night variation to net escapement in the daytime. Wheatland (1956:279) states that net escapement probably accounts in large measure for decrease in percentage of larger sand lance larvae.

The sample mean lengths of sand lance larvae taken from various stations in January and March are shown in Figs. 3 and 4, respectively. Samples obtained in February and April were too fragmentary to be of use in statistical analysis.

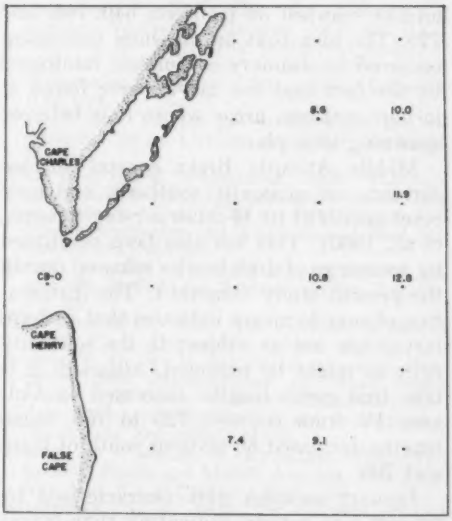

Fig. 3.—Sample mean lengths of larvae of the sand lance, *Ammodytes americanus*,—January, 1960.

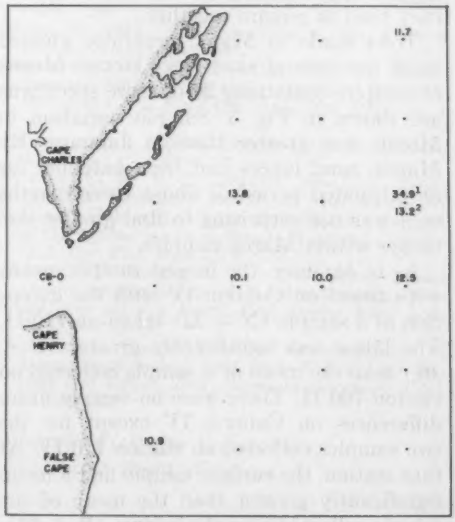

Fig. 4.—Sample mean lengths of larvae of the sand lance, *Ammodytes americanus*—March, 1960. 1) Surface sample 2) Bottom sample.

Sample mean lengths for January were compared on the basis of the *t* test. In every instance, samples separated by a 10-mile interval were significantly different ($P < 0.1$). An off-shore movement of these larvae seems indicated by progressive size increases seaward on transects 640, 700, and 720. The idea that an off-shore movement occurred in January is further reinforced by the fact that few larvae were found at inshore stations, areas where it is believed spawning took place.

Middle Atlantic Bight coastal surface currents are generally southerly and may reach speeds of 10–14 miles per day (Joseph, et al., 1960). This has also been confirmed by recoveries of drift bottles released during the present study (unpubl.). The distribution of sample means indicates that perhaps larvae are not as subject to the southerly drift as might be expected. Although it is true that mean lengths increased on Column IV from transect 720 to 700, mean lengths decreased on stations south of transect 700.

January samples were characterized by narrow size ranges, indicating that larvae of approximately the same age constituted the samples. Evidence from these samples suggest that as larvae are hatched together they tend to remain together.

Tows made in March generally yielded small numbers of sand lance larvae. Means of samples containing 20 or more specimens are shown in Fig. 3. Sample variation in March was greater than in January. By March, sand lances had been hatching for an estimated period of about three months so it was not surprising to find greater size ranges within March samples.

As in January, the largest sample means were found on Column IV with the exception of a sample ($N = 22$) taken on 710 II. The latter was significantly greater ($P < .01$) than the mean of a sample collected on station 700 II. There were no sample mean differences on Column IV except for the two samples collected on station 710 IV. At that station, the surface sample had a mean significantly greater than the mean of the sample collected near the bottom ($P < .01$).

After considering the offshore movement implied by distribution of sample mean lengths it is postulated that larvae are not as subject to surface currents as might be thought. Bathymetric distributions show the capability of larvae to move throughout the water column. It is not implied that larvae continually stem surface currents to maintain latitudinal position but certainly the amount of time larvae occupy surface layers influences the rate at which they may be transported by surface currents. Furthermore, it appears that even in very early stages larvae are partially able to direct their own movement. Such a conclusion is based on several observations: (1) apparent off-shore movement of early stage larvae perpendicular (or nearly so) to the southerly surface drift, (2) retention of rather specific size groups (particularly true in January), and (3) probable net avoidance indicated by relatively few recaptures of sizes > 20 mm.

Meek (1916:253–4) gives an account of the behaviour of young lesser sand eels (*A. tobianus*) which is of interest at this point. He reported that, after hatching (4–5 mm long), lesser sand eels remain in bottom waters, from which they are dispersed by currents from the main spawning grounds. As the larvae increase to 15 mm, they move into surface waters where they remain until a length of 30 mm has been attained. Thereafter they move into the midwater habitat of the adult. Meek noted that lesser sand eels segregate by size but did not state at which length size segregation became apparent.

Conclusions

Plankton sampling in off-shore waters adjacent to Chesapeake Bay resulted in the capture of 3683 sand lance larvae ranging in size from 5 to 48 mm. The greatest number of larvae (75 percent) was caught in January. During the following months, numbers fluctuated until May, when only a single larva was taken.

Larvae were widely distributed over the study area from month to month and in general most of the larvae were caught on the easternmost stations. Larvae were predominant in the surface layers in January, dispersed throughout the water column in February, most prevalent in bottom waters

during March, and again distributed throughout the water column in April.

The dominant size class for January, February, and March was 10–14 mm, with the 5–9 mm size class next in importance. For April there was a shift in the mode to the 15–19 mm size class, with the 10–14 mm group next in importance. There were no larvae of 5–9 mm in the April collection.

Failure of the January dominant size class (10–14 mm) to appear in substantial numbers as larger larvae in subsequent samples has been attributed to a combination of such variables as net escapement, mortality, and emigration.

Statistical analyses of samples suggested that larvae move offshore and that larvae hatched together tend to remain together.

A sample collected in March indicated an average monthly growth rate of 11.7 mm.

It was estimated that hatching commenced in November when water temperatures had declined to 9°C, reached a peak in December, and continued until sometime in March.

From the distribution of larvae 5–6 mm long it appears that spawning took place in waters of 5–12 fathoms.

Although temperature did not appear to play an important role in distribution, data from the collections showed few larvae to be taken from waters of salinities less than 30 ‰.

Contrary to the findings of other students investigating larval fish distribution in estuaries, we found only two sand lance larvae within Chesapeake Bay.

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Investigations of Inner Continental Shelf Waters Off Lower Chesapeake Bay. Part III. The Phorozooid Stage of the Tunicate *Doliolum nationalis*[1,2]

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ABSTRACT

The phorozooid is an almost unknown stage in the asexual generation of the pelagic tunicate *Doliolum nationalis* Borgert. Heretofore, it has merely been reported but not described.

Phorozooids were found in surface meter and half-meter net samples taken in the Atlantic Ocean within 50 miles of the Virginia coast, in December 1959 and July, August and September 1960. The mean length of the December specimens was 2.64± 0.46 mm, that of the July specimens 1.86± 0.21 mm. Except for a smaller average size, the absence of gonadal tissue and the presence of a ventral peduncle, a phorozooid resembles the gonozooid, the hermaphroditic stage.

Introduction

The tunicates described in this paper were found in plankton samples of the ichthyoplankton collection of the Virginia Fisheries Laboratory. These samples were caught in surface meter nets towed by the "Pathfinder", in an area of approximately 2500 square nautical miles extending about 50 miles eastward from the mouth of the Chesapeake Bay and between 36°40′ and 37°30′ north latitude. Ten monthly cruises have been made since December 1959. Tunicates have been found only in the first month and in July, August and September 1960. They were identified by Dr. J. L. Yount[3] as the phorozooid stage of *Doliolum nationalis* Borgert, 1894. Berrill (1950:283) stated that the phorozooid stage of *D. nationalis* had not been fully described.

This species was collected further north in the western North Atlantic than previously had been reported. Bigelow and Sears (1939:270, 271) found doliolids on the continental shelf off Atlantic City, New Jersey, but did not identify them as to species. Their record may have been of *D. nationalis* or one of two others: *D. gegenbauri* var. *tritonis* has been tentatively identified from the September 1960 collection at the Virginia Fisheries Laboratory; or *D. denticulatum* reported by Berrill (1950:283) to have a distribution similar to that of *D. nationalis*, from equatorial Atlantic currents as far north as Bermuda. For the eastern Atlantic, Fraser (1943:3) reported *gegenbauri*, and its variety *tritonis*, and *denticulatum* from Scottish and Irish waters, and *nationalis* from the English Channel. According to Fraser, doliolids, as members of the zooplankton, are indicators of warm Atlantic waters although some are found in colder open ocean waters.

Doliolids are pelagic, free-swimming tunicates (Class Thaliacea, Order Doliolida) (Berrill, 1950:283) which exhibit alternation of generations in their life cycle but never form permanent colonies (Harmer and Shipley, 1904:95). Characteristics of the Doliolidae are the barrel-shaped body with oppositely-placed branchial and cloacal siphons, and the eight encircling muscle bands (Fig. 1).

[1] Contributions from the Virginia Fisheries Laboratory, No. 99.

[2] This investigation was supported by a National Science Foundation grant for Undergraduate Research during the summer of 1960 at the Virginia Fisheries Laboratory, Gloucester Point, Virginia.

[3] Dr. J. L. Yount, P. O. Box 944, Winter Haven, Florida.

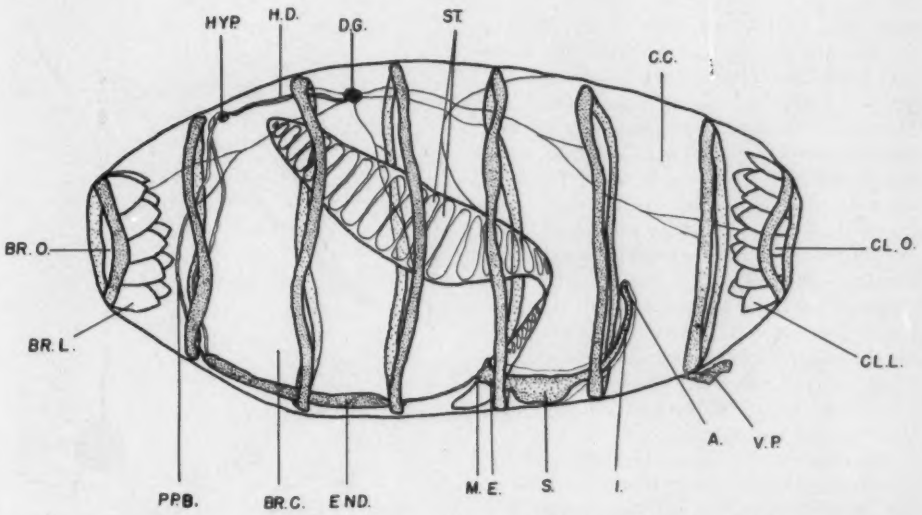

Fig. 1.—Left lateral view of *Doliolum nationalis*. *br. o.*, branchial orifice; *br. l.*, branchial lobes; *pp. b.*, peripharyngeal bands; *br. c.*, branchial cavity; *end.*, endostyle; *m.*, mouth; *e.*, esophagus; *s.*, stomach; *i.*, intestine; *a.*, anus; *v. p.*, ventral peduncle; *cl. l.*, cloacal lobes; *cl. o.*, cloacal orifice; *c. c.*, cloacal cavity; *st.*, stigmata; *d. g.*, dorsal ganglion; *h. d.*, hypophyseal duct; *hyp.*, hypophysis.

Grateful thanks are expressed to the Ichthyology Section of the Virginia Fisheries Laboratory for providing the specimens for study. In connection with all the various preparations of the specimens for study, credit is due Mrs. Lloyd Emory, histologist at the Virginia Fisheries Laboratory, for assistance in histological preparations; and Don Williams, summer aid, for assistance in photography.

Life History

The gonozooid, or sexual, hermaphroditic generation, of *Doliolum* produces ova which are fertilized and develop into oozooids, the asexual stage. In turn, the oozooid goes through a series of changes in which the internal structures degenerate, the eight muscle bands become nine and widen. There is a median dorsal spur (the cadophore) present, as well as a ventral stolon, or "rosette organ" (Harmer and Shipley, 1904:97). From the stolon, buds are constricted which migrate to the spur and settle there in three rows. The two lateral rows form trophozooids, or nutritive forms, which remain attached to the spur and serve only for the benefit of the oozooid. The median row forms phorozooids, or foster forms, which eventually become detached from the spur. A single bud is attached to each phorozooid at its place of attachment to the spur. This bud acts as a generator of buds; the new buds become the gonozooids, the hermaphroditic individuals (Berrill, 1950:281).

Methods

The areas and methods of collection are described by Joseph, et al. (1960:156–7). Certain specimens were stained with Harris hematoxylin and others with toluidine blue. The toluidine blue proved more satisfactory for detailed study of the specimens; Harris hematoxylin was more satisfactory for permanent mounts. Photomicrographs were taken and drawings were made of the specimens stained with toluidine blue.

Phorozooid Stage

The specimens were of the phorozooid stage of *D. nationalis*. This stage is recognized by the absence of gonads and the pres-

ence of a ventral peduncle at the level of the seventh muscle band (Dakin and Colefax, 1940:198) (Fig. 1). However, the majority of the specimens taken from the December plankton samples were lacking the ventral peduncle. These were not early gonozooid stages with undeveloped gonads, for when the gonozooids are liberated from the ventral peduncle of the phorozooid they are already sexually mature (Harmer and Shipley, 1904:99). Yet in the July 1960 plankton samples, the majority of the specimens possessed a ventral peduncle. Possibly the December specimens were later-stage phorozooids from which the peduncle had either been sloughed off or had been absorbed by the animal.

The mean length of the December phorozooids was 2.64 mm, with a standard deviation of 0.46 mm. The July specimens were significantly smaller: their mean length was only 1.86 mm, with a standard deviation of 0.21 mm. The means were significantly different ($P < 0.05$). These phorozooids were

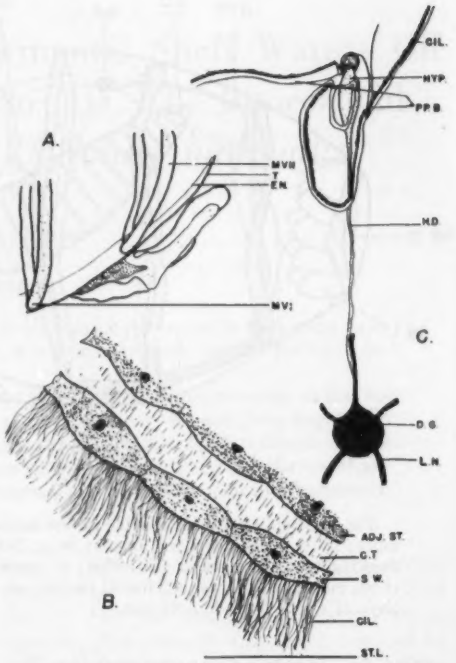

Fig. 3.—A. Left lateral view of ventral peduncle of *Doliolum nationalis*. *MVII*, muscle band seven; *t.*, test; *en.*, endoderm; *M VI*, muscle band six. B. Stigmal walls. *adj. st.*, adjoining stigmata; *c. t.*, connective tissue; *s. w.*, stigmal wall; *cil.*, cilia; *st. l.*, stigmal lumen. C. Hypophysis and dorsal ganglion. *cil.*, cilia; *hyp.*, hypophysis; *pp. b.*, peripharyngeal bands; *h. d.*, hypophyseal duct; *d. g.*, dorsal ganglion; *l. n.*, lateral nerve.

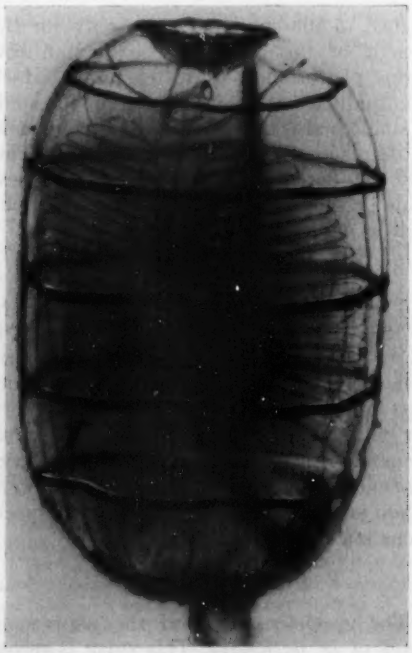

Fig. 2.—Dorsal view of *Doliolum nationalis* showing arrangement of stigmata.

smaller than the gonozooids described by Berrill (1950:283), who gave measurements of the gonozooids generation as 3.00 mm or more.

The stigmata are arranged in bilaterally symmetrical series of elongate perforations in the branchial septum (Fig. 2). This septum is a thin membrane which forms a *C*-shaped band across the body (Fig. 1). There is a sheet of suspensory tissue located between the dorsal body wall and the midline of the branchial septum.

The first pair of stigmata is located near the middle of the second intermuscular space, the last pair in either the extreme back of the fourth or in the front of the fifth intermuscular space.

The stigmal walls are composed of elon-

gated cells which are ciliated on the internal edge bordering the lumen of each stigma (Fig. 3B). The cells are rounded on the internal ciliated edge and more or less flattened on the external edge.

In the December specimens there was a mean number of 27.31 pair of stigmata with a standard deviation of 6.25 pair; whereas in the July specimens there was a mean number of only 19.51 pair with a standard deviation of 2.28 pair. These means were significantly different ($P < 0.05$).

The endostyles of the December specimens had an average length of 0.74 mm with a standard deviation of 0.17 mm. Their mean length was approximately one-quarter of the total body length. The endostyles of these specimens extended anteriorly to the front of the second intermuscular space and posteriorly to the fourth muscle band.

Beginning at the anterior end of the endostyle, two ciliated peripharyngeal bands ascend dorsally to reunite at the dorsal tubercle where the hypophysis is located. Both peripharyngeal bands follow the contour of the body wall in their ascent. Dorsally the left band forms a spiral around the hypophysis. The left band passes in front of the anterior end of the hypophysis and then trends posteriorly, where it joins the right band. This combination then curves medially to the left. The hypophyseal duct extends from the posterior end of the hypophysis and terminates at the subneural gland (Fig. 3C). The right ciliated band, at the posterior end of the endostyle, ascends the posterior pharyngeal wall in the sagittal plane to enter the mouth.

The digestive tube is placed ventrally on the floor of the cloacal cavity slightly to the right of the median line. The mouth is located in the fourth intermuscular space slightly dorsal to the termination of the branchial septum. The esophagus is relatively short and leads into the bulbous stomach. The intestine, which is attached to the right body wall, ascends dorsally with a slight dextral turn, the anus opening into the cloacal cavity in the front of the sixth intermuscular space or in the back of the fifth.

The dorsal ganglion is located in the middle of the third intermuscular space in a medial position. From it arise several pairs of lateral nerves which innervate the eight muscle bands and terminate in sensory organs in the branchial and cloacal lobes as well as in the test.

The ventral stalk or peduncle of the phorozooid is located slightly anterior to the seventh muscle band on the ventral side (Fig. 3A). As previously mentioned, this peduncle marks the point of attachment of the phorozooid to the spur of the oozooid.

Discussion

The phorozooid stage of *D. nationalis* resembles the gonozooid except for the lack of gonadal tissue and the presence of the ventral peduncle. In all other respects, the phorozooid has essentially the same anatomy as the gonozooid.

According to Harmer and Shipley (1904: 97), "when stigmata are found in the lateral walls of the branchial sac, there are corresponding anteriorly directed diverticula" of the cloacal cavity. This statement suggests the absence of a cloacal sac, for there is only one anterior limiting wall between the cloacal and branchial cavities—the branchial septum. However, this is not a perpendicular structure, because there are two anteriorly directed diverticula of the cloacal cavity dorsal to the septum. These diverticula are separated by a dorsal suspensory sheet of tissue which, like a mesentery, supports the branchial septum.

The number of stigmata in the phorozooid had not been previously reported; neither had the size of this stage. There was a considerable difference between the number of pair of stigmata in the December 1959 specimens and in the July 1960 specimens. Similarly, there was a noticeable difference in the mean lengths of the two groups of specimens. These suggest that the July 1960 specimens were of a newer generation than the December 1959 specimens. Since the ventral peduncle is present in phorozooids which have just been detached from the oozooid, the lack of this peduncle in larger specimens suggests a sloughing off or absorption of the peduncle. The absence of this peduncle on the Decem-

ber specimens suggests a more mature phorozooid, whereas the presence of the peduncle on the July specimens implies that the latter were of more recent origin.

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Reduced Oxygen Tolerance and Toxicity of Petroleum Products to Juvenile American Shad

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ABSTRACT

Experiments were conducted on juvenile American shad, *Alosa sapidissima*, to indicate tolerance to reduced oxygen, toxicity of petroleum products, and toxicity of petroleum products with accompanying low dissolved oxygen. All mortalities in reduced oxygen tests occurred at dissolved oxygen values of less than 2 ppm with lethal concentrations varying with the rate of reduction. No mortalities occurred when dissolved oxygen was maintained between 2 and 4 ppm. TL_m (median tolerance limit) values were determined for gasoline, diesel fuel oil, and bunker oil for 24- and 48-hour periods. Gasoline was the most toxic, fuel oil somewhat less toxic, and bunker oil least toxic. The lethality of petroleum products to shad was found to increase when accompanied by low dissolved oxygen.

Introduction

The commercial yield of American shad, *Alosa sapidissima*, on the Atlantic coast decreased from a peak of 50 million pounds in 1896 to a low of 8 million pounds in 1950. In certain coastal rivers, part of this depletion has been attributed to pollution and low oxygen content. Studies of shad in the Hudson and Delaware Rivers (Talbot, 1954:401–9; and Sykes and Lehman, 1957: 14–21) indicated that oil, domestic sewage, and industrial wastes had caused a reduction in the dissolved oxygen content of the water to a degree possibly detrimental to this species. Large numbers of young shad and herring died as a result of sewage pollution in the Delaware River near the Torresdale Pumping Station during the fall of 1950 (Fishing Gazette, 1950). Lane, et al. (1926:177) quoted the Commissioner of Fisheries of the Commonwealth of Pennsylvania, who said that surveys along the tidal section of the Delaware River indicated that oil and sludge from refineries and oil-carrying vessels were the main cause for the decline in numbers of shad in that region.

It has been established by various workers that oil pollutants are toxic to fish and marine invertebrates. Westfall (1943:5) found that goldfish became sluggish, lost equilibrium, and refused food when exposed to an oil effluent which was being discharged into the Buffalo River. Chipman and Galtsoff (1949) showed the toxic effects of oil on various forms of marine life. Roberts (1926) found that both gas oil and diesel oil were toxic to fish and attributed their toxic action to water soluble constituents and emulsions.

Studies were conducted on juvenile shad by the Bureau of Commercial Fisheries to indicate tolerance to reduced oxygen, toxicity of petroleum products, and toxicity of petroleum products with accompanying low dissolved oxygen. Investigations were exploratory and the results are considered indicative rather than definitive in application to the diverse conditions found in nature.

The American shad is anadromous, and sexually mature adults enter Atlantic coast rivers from the sea to spawn in late winter and spring. The young spend their first summer in the rivers (5 to 6 months) and then migrate to the ocean. In 3 to 6 years they reach sexual maturity and return to their native rivers to spawn. Shad of northern rivers that escape the fisheries spawn, return to the ocean, and are free to re-enter the river the following year provided they undergo no mortality. Those that spawn

in rivers south of Chesapeake Bay, and particularly south of North Carolina, die after spawning (Talbot and Sykes, 1958: 485).

Gerald B. Talbot, Director, Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N. C., initiated this study, and the shad staff aided in collecting fish. Appreciation is expressed to G. E. Burdick, New York Conservation Department, and Charles M. Weiss, University of North Carolina, for reading the manuscript and for offering suggestions on treatment of the data.

Materials

Juvenile shad were obtained by seine from the Neuse River near New Bern, N.C., during September and October 1958–59. Fish were transported to the laboratory in a tank mounted on a truck as described by Sykes (1950). Suggestions by Doudoroff, et al. (1951) were followed in caring for and preparing test fish in the laboratory.

Three aquaria having glass sides were used in the experiments. Two aquaria served as experimental tanks and one as a control. The sides of each aquarium were covered with cardboard to shield fish from outside disturbance. In each test, 30 gallons (113.6 liters) of water from the seining site and 10 shad were placed in an aquarium. The specific gravity and pH of the experimental water ranged from 1.0028 to 1.0063 and from 7.4 to 7.6, respectively. Fork lengths of the test fish ranged from 55 to 72 mm (average length 66 mm) and weight ranged from 2.1 to 4.0 gms.

Methods

Four experiments were conducted in which dissolved oxygen was reduced to determine concentrations at which young shad could live and those which caused mortalities, and a fifth experiment was conducted to determine tolerance to low oxygen for a sustained period. Preliminary tests were made to resolve methods and obtain hypotheses for tests. Aquarium water was aerated to provide an initial dissolved oxygen of 7.0 ppm. Controls with oxygen maintained at or slightly more than 7.0 ppm were run simultaneously with these experiments.

Initial oxygen concentration was reduced by the test fish in open and covered aquaria. In the first and second experiments, reduction occurred slowly because of partial replacement of oxygen at the water surface from the atmosphere. In the third and fourth experiments, dissolved oxygen was reduced rapidly by covering the water surface with a layer of wax paper which prevented atmosphere-water exchange of oxygen. An experiment was terminated when a 50 per cent mortality occurred. Cessation of respiratory movement was considered as the criterion of death. In the fifth experiment, dissolved oxygen was reduced slowly by the test fish and maintained for 96 hours between 2.0 and 4.0 ppm. During this latter test, artificial aeration was required for short periods to maintain a minimum oxygen content of 2.0 ppm.

Water temperature and dissolved oxygen were determined at varying intervals (usually hourly after initial fish distress) during each experiment. Oxygen determinations were made using the micro-Winkler method as described by Welch (1948:211); a 25 cc sample of water was removed for each analysis from below mid-depth. Dissolved oxygen was 0.1 ppm greater in water at the surface of the aquarium than at mid-depth or bottom; however, the effect of this slight variation on the fish, which showed no depth preference, was considered insignificant.

Bio-assays were conducted to determine the toxicity of petroleum products to juvenile shad. The methods used were as prescribed by the Federation of Sewage and Industrial Wastes Sub-committee on Toxicity (Doudoroff, et al., 1951). Three series of experiments were conducted using regular grade gasoline (specific gravity 0.7953); grade No. 2 diesel fuel oil (specific gravity 0.8710); and Class C, grade No. 6 bunker oil (specific gravity 0.9698). Preliminary tests were made with different concentrations of each pollutant to determine the approximate range of toxicity. In the final experiments, the TL_m (median tolerance limit—concentration that causes 50 percent mortality) values were determined for 24- and 48-hour periods by straight line graphic

interpolation using semilogarithmic paper. A control free from pollutant was run concurrently with each test.

A measured quantity of pollutant was added to the surface of the water in each test. The water in each aquarium was circulated at a rate of 1 gallon per minute with an electric pump and ½" diameter plastic tubing. Water was drawn from the bottom of the aquarium and diffused upon re-entry into the tank by flowing over an 8" x 15" perforated platform suspended directly above the surface of the water. Experimental water was therefore allowed to permeate the pollutant and extract any toxic water-soluble substances. The pattern of water circulation was an attempt to simulate current action and mixing of water under natural river conditions. In all experiments dissolved oxygen remained more than 6.0 ppm because of the method of water circulation.

Two experiments were conducted to determine the combined effects of low dissolved oxygen and petroleum toxicity on juvenile shad. In both tests the initial dissolved oxygen content of aquarium water was 6.5 ppm, and this was reduced at a rate of 1.0 ppm per 10 hours to 2.5 ppm by respiratory activity of the fish. In the first experiment, gasoline (68 mg/l) was then added to the surface of the water and in the second experiment, diesel fuel oil (84 mg/l) was added. The petroleum concentrations used were those in which no shad mortality occurred within 24 hours as determined in the bio-assay evaluation of the toxicity of these pollutants. The water in the aquarium was then circulated in the same manner as described in the petroleum toxicity tests. After the addition of oil, dissolved oxygen was maintained between 2.0 and 3.0 ppm for the duration of each test. To counterbalance an increase in oxygen caused by circulation of the water, compressed nitrogen was released into the aquarium using an air mist releaser. This method of decreasing oxygen is a physical process involving its dissolution from the aqueous phase into the gaseous phase in accordance with Henry's Law (Carpenter and Cargo, 1957:7). Dissolved oxygen was determined at approximately 10-minute intervals after addition of oil. Oxygen levels were maintained within the desired range by adjustment of nitrogen flow. Experiments were terminated after total mortality of test fish. A control free from oil and with oxygen maintained between 2.0 and 3.0 ppm was run in conjunction with these tests.

Free CO_2 and pH were determined at the beginning and end of each experiment. In the reduced oxygen studies, free CO_2 values were usually less than 5 ppm and never exceeded 10 ppm. Free CO_2 remained less than 3 ppm in the petroleum toxicity studies. The pH range in all tests was from 7.4 to 7.6, and water temperatures were between 21° and 23° C.

Results

Reduced oxygen experiments 1 through 4 (Table 1) revealed that when oxygen was reduced at a slow rate (1 ppm per 9½ and 11 hours), all mortalities occurred at less than 1.2 ppm, and when reduced at a more rapid rate (1 ppm per 3 hours), all mortalities occurred at more than 1.3 ppm. The fish remained schooled during the experiments until in distress. Individuals left the school at an oxygen concentration of 1.4 ppm when oxygen was lowered slowly, and at 2.4 ppm when lowered rapidly. Symptoms of distress were labored respiratory movements, violent gulping at the surface, sudden rapid swimming, and loss of equilibrium. Respiratory movements became more rapid as dissolved oxygen was reduced below 4.0 ppm. Fish surviving these experiments were in intense distress at the termination of each test.

TABLE 1.—Tolerance of juvenile American shad, *Alosa sapidissima*, to continuous reduction of dissolved oxygen, experiments 1–4.

Average rate of oxygen decrease from 7 ppm	Dissolved oxygen first mortality (ppm)	Hours elapsed	Dissolved oxygen 50% mortality (ppm)	Hours elapsed
1 ppm per 9½ hours	1.0	55.5	0.9	57.5
1 ppm per 11 hours	1.1	65.0	0.9	68.0
1 ppm per 3 hours	1.8	15.0	1.4	16.5
1 ppm per 3 hours	1.6	16.0	1.4	17.5

TABLE 2.—Tolerance of juvenile American shad, *Alosa sapidissima*, to sustained levels of reduced dissolved oxygen, experiment 5.

Dissolved oxygen[1] (ppm)	Hours maintained	Mortality
3.0–3.8	54	0
1.8–2.9	42	0

[1] Initially reduced from 7.0 to 3.8 ppm at a rate of 1 ppm per 12½ hours.

In experiment 5 (Table 2) juvenile shad were tolerant to dissolved oxygen maintained between 1.8 and 3.8 ppm for a 96-hour period. No distress except for more rapid than normal respiratory movements was noted among the test fish during this time. One death occurred in the controls run in conjunction with the reduced oxygen experiments. Other than this exception, control fish remained schooled and appeared in good condition.

In bio-assay studies on toxicity of petroleum products (Tables 3 and 4), gasoline, diesel fuel oil, and bunker oil were toxic to juvenile shad. The lighter petroleum products were comparatively more deadly than the heavier oils. Gasoline was most toxic, fuel oil somewhat less toxic, and bunker oil least toxic. A narrow critical concentration range (interval between highest concentration at which all fish survive for 48 hours, and the lowest concentration at which all die within 24 hours) occurred for gasoline. This range was between 68 and 114 mg/l. The toxicity of bunker oil was not sufficiently pronounced in this study to allow determination of the 24-hour TL_m using the highest concentration that could be properly tested. Concentrations of bunker oil greater than 2,500 mg/l formed a heavy oil layer on the surface of the aquarium which hindered water circulation.

The reaction of juvenile shad to toxic concentrations of each petroleum product was typically the same. Distress was first noted when individuals broke from the school to swim and probe at the surface. The fish next displayed loss of equilibrium by swimming inverted, tails down, on their sides, or with an arch in their bodies. Intensity and duration of distress varied with type and concentration of pollutant. The period from initial distress to death was within 1 hour with gasoline, 5 to 10 hours with fuel oil, and 12 to 18 hours with bunker oil. No mortality or distress occurred among control fish.

Specific concentrations of petroleum products and levels of reduced oxygen, found tolerable in these studies, were found to be lethal in experiments where they occurred together (Table 5). Distress and dispersion of test fish occurred 30 minutes after addition of gasoline and 120 minutes after addition of diesel fuel oil. After initial distress, mortalities occurred in 10 to 30 minutes with gasoline and in 60 to 180 minutes with diesel fuel oil. No deaths occurred in the

TABLE 3.—Survival of juvenile American shad, *Alosa sapidissima*, subjected to different concentrations of petroleum products for specified time intervals (10 fish used in each test).

Petroleum product	Concentration mg/l	Number surviving after		
		24 hours	48 hours	96 hours
Gasoline	152	0	0	—
	114	0	0	—
	99	2	2	—
	84	8	8	—
	68	10	10	—
	38	10	10	—
Diesel fuel oil	334	2	2	—
	251	3	2	—
	167	7	5	—
	125	8	7	—
	84	10	9	—
Bunker oil	2,417	8	5	2
	1,952	10	8	5
	1,580	10	9	7
	1,302	10	10	10
	837	10	9	9
	372	10	10	10

TABLE 4.—TL_m (median tolerance limit) values of gasoline, diesel fuel oil, and bunker oil for juvenile American shad, *Alosa sapidissima*.

Petroleum product	TL (mg/l)		
	24 hour	48 hour	96 hour
Gasoline	91	91	—
Diesel fuel oil	204	167	—
Bunker oil	—	2,417	1,952

control where dissolved oxygen was maintained between 2.2 and 3.3 ppm for 5 hours. The control was maintained at more than 6.0 ppm for an additional 48 hours, and no delayed mortality occurred.

Discussion

The reduced oxygen experiments indicate that young American shad in unpolluted waters are able to acclimate to low oxygen concentrations dependent on the rate of reduction. Shepard (1955:425, 430) found that in brook trout acclimation to low oxygen was accompanied by an increase in the ability of the fish to extract oxygen. This acclimation would aid fish to survive exposure to low levels of dissolved oxygen for short periods. The present study indicates that young shad can probably survive limited exposure to dissolved oxygen between 2.0 and 4.0 ppm in natural waters where other environmental conditions are satisfactory. However, these low levels over prolonged periods may not be adequate for normal activity and growth and may exert a deleterious effect when in combination or interaction with other unfavorable environmental stresses. In terms of a single standard, a minimum dissolved oxygen of 5.0 ppm has been established by Ellis, et al. (1947:12–3) and 4.0 ppm has been suggested by Burdick (1954:204) for the wellbeing of shad.

Ellis (1946) found less reduced oxygen tolerance for juvenile American shad than shown in these experiments. Using 4-liter flasks containing one to five fish each, he found that a mortality rate of approximately 49 percent occurred when dissolved oxygen was reduced from 5.0 to 3.0 ppm at temperatures ranging from 20.2° to 22.5° C. Ellis reduced the oxygen level using a partial pressure apparatus at the rate of 1.0 ppm per 10 to 40 minutes. The method used and the rapidity of reduction probably account for the early mortalities.

The death-causing effects of petroleum products on juvenile shad were not ascertained in this study; however, loss of equilibrium exhibited by the fish indicated possible disturbance to the central nervous system. Ellis (1937:402), in classifying pollutants on the basis of locus of injury to the fish, stated in part that various volatile crude oil compounds can enter the body of fish through external structures such as gills and lining of the mouth. Gutsell (1921:7) stated that if a surface layer of oil is emulsified by agitation, it may coat the gill membranes of fish and cause death by suffocation. During the bunker oil tests, many small particles broke free from the surface oil layer and became suspended in the water. The gills of the fish examined at the termination of these tests were covered with many of these particles, which could have caused death by suffocation. From these limited studies, the cause of death from petroleum products appears to be in part physical and in part toxicological.

TABLE 5.—Combined effects of reduced oxygen and petroleum toxicity on juvenile American shad, *Alosa sapidissima*, experiments 1–2.

Petroleum product	Concentration (mg/l)	Dissolved oxygen (ppm)	Minutes elapsed	
			50% mortality	Total mortality
Gasoline	68	2.6–3.2	50	60
Diesel fuel oil	84	1.9–3.1	270	300

Diesel fuel oil, and especially gasoline, seemed to lose some of their toxic properties before the conclusion of a test. The 24- and 48-hour TL_m derived from the gasoline experiments were the same. Roberts (1926: 271–3) found that on exposure to air, extracts of gas oil and diesel oil lost much of their toxicity and attributed this to a possible loss of toxic volatile substances or to the oxidation of the toxic substances. Determining the chemical nature of the various petroleum products, although not attempted in the present study, evidently is important in the evaluation of their effect.

A synergistic relation appears to exist between the combined effects of low oxygen and oil pollution that increases their toxicity to fish. Oil concentrations that are tolerable to fish when accompanied by high oxygen levels probably become lethal when oxygen is just adequate for fish survival. As pointed out by Beak (1958:567–70), it has been demonstrated experimentally by various workers that the lethality of certain toxic substances is increased by accompany-

ing low dissolved oxygen conditions. In the case of oil pollution, low oxygen may be directly due to the oil pollutant. A surface oil layer retards air-water exchange of oxygen, and it is known that crude oils absorb this gas (Roberts, 1926:253). Doudoroff (1957:413) reported that high temperatures, extremes of pH, high concentrations of free CO_2, and certain other toxic substances can greatly increase the susceptibility of fish to low dissolved oxygen in natural waters.

Conclusions

1. Experiments were conducted on juvenile shad to indicate tolerance to reduced oxygen, toxicity of petroleum products, and the effect of reduced oxygen on toxicity of petroleum products.

2. Each test consisted of 10 shad in 30 gallons of water. In the reduced oxygen tests, oxygen was lowered by the test fish at different rates in open and covered aquaria or was maintained at desired levels by artificial aeration. In petroleum product bio-assays, water in each aquarium was circulated to permeate the pollutant added to the surface. Experiments on combined effect of reduced oxygen and petroleum products were conducted in the same manner as the above, and desired low levels of oxygen were maintained by addition of nitrogen.

3. Fifty percent mortality resulted at an oxygen concentration of 0.9 ppm when initial oxygen was reduced at a rate of 1.0 ppm per 9½ and 11 hours and at 1.4 ppm when oxygen was reduced at a rate of 1.0 ppm per 3 hours. No deaths occurred when dissolved oxygen was maintained between 1.8 and 3.8 ppm for 96 hours.

4. The 48-hour TL_m (median tolerance limit) values determined in the evaluation of toxicity of petroleum products to juvenile shad were 91 mg/l gasoline, 167 mg/l diesel fuel oil, and 2,417 mg/l bunker oil.

5. Petroleum product concentrations that were tolerable to juvenile shad when accompanied by dissolved oxygen greater than 6.0 ppm were lethal at oxygen levels ranging from 1.9 to 3.2 ppm.

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Some Physiological Characteristics of the Heart of the Toadfish, *Opsanus tau*[1]

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ABSTRACT

A study was made of the heart from *Opsanus tau* using an electrocardiograph to record normal activity and the responses to drugs and to experimental manipulations. Bradycardia occurs in toadfish kept out of water for more than 5 minutes. Large doses of darstine, an atropine-like drug, bring about A-V dissociation and prolongation of conduction time, probably by direct action on the heart muscle. Changes in temperature modify the heart *in vitro* and *in situ*.

Introduction

Fishes are what might be called representatives of a generalized vertebrate type. The heart in a fish is relatively simple compared with that of higher vertebrates. One notices that there is a dearth of information on the comparative physiology and pharmacology of the heart in the intact fish (Mott, 1957). There are a number of publications dealing with the effects of temperature and other physical factors in the environment on the functioning of the isolated or of the developing heart (Grodzinski, 1951; Keys, 1931). In addition, the isolated heart of the fish has been used to study the effect of various drugs on protoplasm (Huntsman, 1931; Otorii, 1953).

It is obvious that the isolated heart is not in an ideal physiological condition. It, therefore, seemed proper that further investigations be made on the functional characteristics of the fish heart *in situ*. In order to do this work, it was necessary to have a species of fish that was readily available and one that keeps well in an aquarium. An ideal species would be one that resists the experimental manipulations that are required for a study of this sort. For these reasons, the toadfish, *Opsanus tau*, was chosen. This present paper reports the results of certain experiments made on the heart in the intact toadfish.

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Materials and Methods

The toadfish used in the experiments were obtained from the Patuxent River at the Chesapeake Biological Laboratory, Solomons, Maryland and the Supply Department of the Marine Biological Laboratory at Woods Hole, Massachusetts. They were kept in running sea water in a glass aquarium. Needle electrodes were used, following the method suggested by Kisch (1948) for obtaining electrocardiograms of fish. The symbols used below (P-Q, R-T, and P-R) are intervals between waves produced during the cardiac cycle. Blood pressures were measured with a mercury manometer. Stainless steel cannulae were inserted into various parts of the vascular system to pick up localized end pressures. In a few experiments, lateral pressures were measured. A column of isotonic saline containing heparin connected the blood through the cannulae to the mercury column in the manometer. A few experiments were performed to compare the electrical activity of the heart *in situ* with the activity of that same heart after it had been removed from the body of the fish and perfused with isotonic saline solution. The effects of prolonged removal from the water on the toadfish heart were also recorded.

Results

Table 1 illustrates the effect on the heart beat in the toadfish of exposure of the entire fish to air. The water temperature in

which the fish had been kept was 19°C and that in the gill cavities was also 19°C. At that time the breathing rate of the fish, which essentially is the direct measure of the opening and closing of the operculum, was approximately 25–27 breaths per minute. This opening and closing was picked up on the electrocardiogram. The room temperature at which the fish was exposed was 23°C. It is evident that the heart rate decreased steadily with increased exposure to air. The P-Q interval, which gives some idea of the condition of the conducting system of the heart, increased by about 15 per cent during the exposure (Table 1). If the fish was removed from water, and a stream of sea water was directed into the mouth and across the gills, the heart rate was maintained at a normal rate and the P-Q interval showed no significant changes for 45 minutes (Table 2).

Table 3 illustrates a typical experiment in which the heart of the toadfish was isolated from the body. The heart was quickly removed from the fish and put into a shallow glass container which held a saline solution 0.15 molar in concentration (Green and Hoffman, 1953). A small amount of heparin was added to the saline. Stainless steel electrodes were then immersed in the saline in the vicinity of the heart. A 2:1 heart block developed soon after immersion in the bath. It is evident that the atrial or pacemaker rate is exactly twice that of the ventricular rate after about 10 minutes in the isolating bath.

The effect of Serotonin on the intact heart of the toadfish is illustrated in Fig. 1. There is some indication that an injection of 1 milligram of Serotonin directly into the pericardium causes a transitory increase in heart rate, a persistent increase in the R-T interval and a prolongation of the

TABLE 1.—The effect of exposure to air on the heart in the toadfish, *Opsanus tau*. Water temperature from which removed was 19°C; room temperature at which exposed was 23°C.

Time, hours	Beats per minute	P-Q Interval, second
1455	47	.26–.28
1500	39	.32
1505	37	.28
1515	32	.30
1525	25	.30

TABLE 2.—The heart rate in a typical toadfish, *Opsanus tau*, removed from the water but with gills exposed to a stream of water. Heart rate recorded by electrocardiograph.

Time, minutes Immediately after removal from water	P-Q Interval, second	Heart Rate, beats/min.
	.28	75
4	.26	65
8	.28	60
10	.28	45
18	.26	43
25	.28	45
35	.28	43
45	.28	51

TABLE 3.—Isolated heart of toadfish, *Opsanus tau*, in 0.15 M sodium chloride containing heparin. Room temperature and temperature of bath, 25°C.

Time, hours	Ventricular rate	Atrial rate	P-Q Interval, seconds
1015[1]	75	75	?
1025	34	68	.48
1030	30	60	.56
1037	28	56	.60
1043	26	52	1.36
1048	20–24	48–50	Variable
1056	Fibrillation	—	—

[1] Immediately after removal from the animal and immersion in the saline bath.

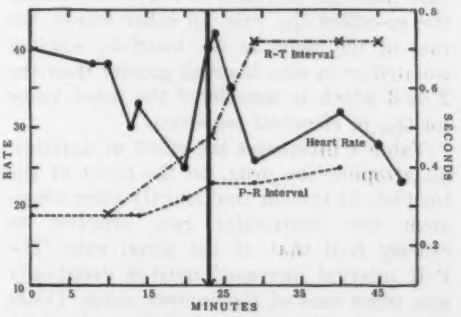

Fig. 1. Effect of 1 milligram Serotonin injected into the heart of the toadfish. Time is given in minutes; heart rate in beats per minute; other measurements in seconds. The heavy vertical line at the 23 minute point indicates the time at which the injection of Serotonin was made.

P-R interval. A similar injection of 0.15M sodium chloride brought about no particular change in the heart rate nor in the other measurements which were made and illustrated in Fig. 1.

Temperature exerts a significant effect on the heart in the intact toadfish as well as on the heart that has been isolated from the body (Fig. 2). It is apparent that the rates of the isolated and of the intact heart increase with increasing temperatures. The slope of the curve describing the increase in the isolated heart is extremely steep. The slope of the line describing the increase in the intact heart is not so steep. In neither case does the increase in heart rate follow the so-called Q_{10} rule. In other words, the rate of the heart in the toadfish, whether isolated or *in situ*, is much greater than the 2 or 3 which is considered the usual value for Q_{10} in chemical reactions.

Table 4 illustrates the effect of darstine, an atropine-like drug, on the heart of the toadfish. It is clear that shortly after treatment the ventricular rate dropped to exactly half that of the atrial rate. The P-R interval increased until it eventually was twice that of the control value. Doses of darstine less than the above brought about no measurable change in the toadfish heart. Decamethonium and atropine were administered to 12 different toadfish in doses up to 30 mg with no measurable cardiac response.

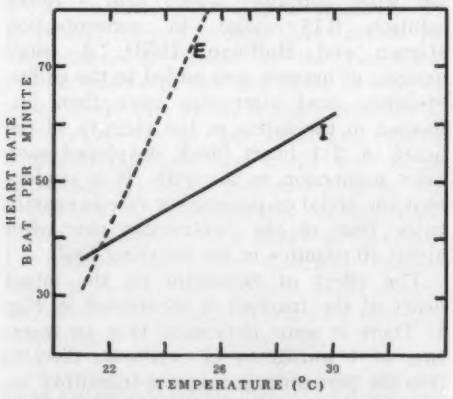

Fig. 2. Effect of temperature on the rate of the toadfish heart *in situ* (I) and isolated in a saline bath (E).

TABLE 4.—The effect on the heart of the toadfish, *Opsanus tau*, of 50 mg of darstine administered intraperitoneally.

Time	Heart Rate Atrium	Heart Rate Ventricle	P-R Interval	R. R. Interval
minutes	beats/min		second	seconds
control	48	48	0.40	1.24
1	51	51	0.36	1.16
3	52	52	0.44	1.16
5	52	26	0.48[1]	2.28
8	54	27	0.60[1]	2.24
15	52	26	0.60[1]	2.36
23	50	25	0.56[1]	2.44
37	46	23	0.68[1]	2.60
50	44	22	0.84[1]	2.80
70	40	20	0.76[1]	2.96

[1] When a ventricular complex follows a P-wave, this is the P-R interval.

The maximum ventricular blood pressure measured in these experiments with the toadfish was 20 millimeters of mercury. Pulse pressures of about 1–2 millimeters of mercury were common. Because of the structure of the operculum it is well nigh impossible to make direct blood pressure measurements in the gill arches. In the specimens of toadfish studied in this investigation, the blood pressure in the conus of the heart did not vary significantly from that found in the ventricle.

In the toadfish heart, one is faced with a strange situation. Injections of large doses of atropine or darstine result in no acceleration of the beat. It may be that at 20°C, which was the average temperature at which these experiments were conducted, the untreated heart muscle is pulsating at the highest rate possible and the blocking action of vagal inhibitory elements is futile. It is, of course, possible but improbable that in the toadfish vagal inhibition is noncholinergic. A massive dose of darstine inhibited the heart rate probably through a direct action of the drug on the cardiac muscle and conducting system.

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A Potomac River Shad Fishery, 1814–1824[1]

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ABSTRACT

The original record books of George Chapman, Esq., haul seine fisherman for American shad, *Alosa sapidissima*, in the Potomac River during the period 1814 to 1824, include the numbers of shad and herring, *A. aestivalis* and *A. pseudoharengus*, caught and sold each day. From the numerous miscellaneous notes included in the records, estimates of fishing effort were made.

Yearly shad catches ranged from 27,939 to 180,755 fish, while the numbers of herrings caught and sold ranged from 343,341 to 1,068,932. The estimated catch per haul was 800 shad in late March, 2250 in mid-April, and 1200 per haul in late May. During the 11-year period almost one million shad were taken.

Catches from this fishery were equal to about one-third of the catch of shad by all gears from the Potomac River during a 11-year period (1946–56). Other species were undoubtedly captured, but were not sold. Fishing for shad in the early 1800's was evidently far more lucrative than it is at the present time.

Introduction

Descriptions of Chesapeake Bay fisheries obtained from historical accounts generally refer to the vast numbers of fishes present in colonial times. Seldom do these old accounts mention actual numbers caught, and rarely the amount of effort expended in their capture. Therefore, except in general terms, it has not been possible to compare on a quantitative basis catches in modern times with those made in earlier days. Recently the "fish books" of George Chapman, Esq., fisherman for American shad, *Alosa sapidissima*, on the Potomac River during the early 1800's were made available for study. These original records include daily entries on the numbers of shad and herrings, *Alosa aestivalis* and *A. pseudoharengus*, caught and sold, and their market value. In addition, the books also contain a wealth of detailed notes pertaining to the fishery. From Chapman's notes, the amount of effort required to make these catches has been estimated and much valuable and interesting information concerning this fishery has been accumulated.

The history of shad fishing in the United States has been admirably reviewed by Mansueti and Kolb (1953). Although their remarks concerning the Potomac River are especially pertinent, information on fisheries during the early 1800's is only general in scope. Pearson (1942–1944) reviewed the origin and development of fisheries in Virginia waters from 1607 to 1800. Since 1880 the U. S. Commission of Fisheries and its successors, the Bureau of Fisheries and U. S. Fish and Wildlife Service, have gathered records on many fisheries including shad. McHugh and Bailey (1957:53–6) summarized much of this information for Virginia waters. Hildebrand and Schroeder (1928:17–32) reviewed shad catches from pound nets located near the mouth of the Bay for the period 1902 to 1922. The Potomac River shad fishery was emphasized in a recent study of the American shad in Chesapeake Bay by Walburg and Sykes (1957:15–24). Little information is available on fisheries during the early 1800's.

Acknowledgments:—Chapman's fish books were obtained through the efforts of Mr. James Wharton, U. S. Bureau of Commercial Fisheries, Weems, Virginia. Mr. Elgin Dunnington, Chesapeake Biological Laboratory, Solomons, Maryland suggested the location of the fishery and toured the area with the author. Mr. Patrick C. Mudd, Clerk for Charles County, Maryland furnished evidence which indicated that Chapman's Point was actually the location of

[1] Contribution No. 98, Virginia Fisheries Laboratory, Gloucester Point, Virginia.

George Chapman's fishery. Dr. Romeo Mansueti of the Chesapeake Biological Laboratory, Solomons, Maryland, and Mr. Charles Walburg of the U. S. Biological Laboratory, Beaufort, North Carolina, were most helpful in suggesting improvements in the manuscript.

Materials and Methods

The primary sources of material were the "fish books" of George Chapman, Esq. These two leather-bound volumes written in the meticulous and rather ornate script characteristic of the period were the actual business records of this fishery. Although 1814 was the first year records were listed in these books, there is little doubt that the fishery had been operating for some time prior to that date. Earlier records were probably lost. The available books contained entries until 1829. Since those later than 1824 seemed incomplete, they were not used. In them were listed the names of all customers, market boat captains, and others concerned with the business of the fishery. Chapman recorded the dates and details of all business transactions under the name of the individual concerned. The validity of the records is indicated by their use, in several instances, as evidence in lawsuits to obtain payment from delinquent customers.

Since shad and herring are notoriously perishable and ice was not used to prevent spoilage, it has been assumed that all fishes sold on a particular day were captured the same day. When catches were extremely large, it was probable that all shad and herring could not be sold. The records, therefore, should be considered as minimum catches. No records were kept on the amount of effort expended in making these catches. The notes do suggest, however, that the catch from each seine haul was shipped to market in a single market boat. The daily number of seine hauls has been estimated from the number of market boats loaded each day. If single catches were split among several market boats, the number of hauls would be smaller than indicated. If catches from several hauls were sent to market in a single boat, the number of hauls would be larger than indicated. No fishes were shipped to market when catches were extremely small, being sold locally instead. It has been assumed that only a single haul was made on such days.

Description of the Fishery

George Chapman owned an estate on the Maryland shore on the Potomac River near Indian Head, 13 miles downriver from Alexandria (Fig. 1). According to the Charles County Index of Records, the 121 acre estate was purchased by George Chapman in 1794. The estate, including the water front and an ideal stretch of landing beach on which the fishery was located, was owned by the Chapman family for several generations. In 1875 J. W. Milner (1876: 351–2), while on a survey of Potomac River fisheries, stopped at the fishery and was entertained for the night by John Chapman. Chapman's Point has been the location of an important shad fishery since colonial times; only in recent years has shad fishing been discontinued there.

Fishing for shad and herring generally began in early April and continued until

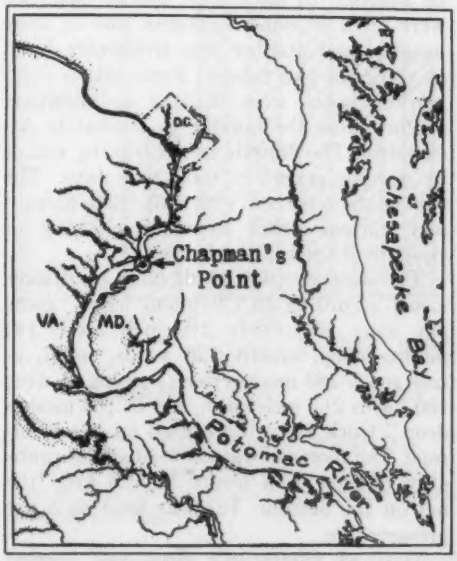

Fig. 1.—Location of Chapman's Point on the Potomac River estuary where the fishery for American shad, *Alosa sapidissima*, and river herrings, *A. aestivalis* and *A. pseudoharengus*, was prosecuted from 1814–1824.

mid-May. During the peak of the run, hauling was done every day including Sundays. Extremely windy, stormy, or cold weather interfered with fishing and sometimes prevented it. Hauling was probably done most frequently at high slack water, as is generally the case at present, but fishing was also done at the other stages of the tide. This part of the estuary is usually tidal fresh or slightly brackish water. Chapman occasionally formed a temporary partnership with another haul seiner, William B. Alexander, who fished at a different landing. Except for these times, when catches were being made simultaneously with both nets, the records refer only to catches made by Chapman's gear.

Hauling was done by slaves. Chapman undoubtedly owned a few, but most were rented by the week from neighboring landowners. A fishing camp was established on the beach near the hauling grounds where the seine haulers lived during the fishing season. The crew varied from five or six men at the beginning and end of the season to about 30 men when fishing was intense. In addition to the slaves, one or two men were hired as seine managers, one as seine mender, and another was frequently hired as clerk for the fishery. From six to eight market boats were utilized to transport catches from the landing to market in Alexandria. The 26-mile round trip, by sail or by rowing generally took two days. The run boats returned with salt, fish barrels, and various other items of clothing or equipment used in the fishery.

The seine was 350 yards long. Its dimensions, according to Chapman were, "going out wing 130 yards 2½ inch mesh 144 meshes deep, middle 120 yards, small, 2-inch mesh 180 meshes deep, coming in wing 100 yards 2½ inch mesh, 144 to 168 meshes deep." Cork floats were used on the headrope. The footrope was not leaded, but probably hung with a heavy line to keep the net on the bottom. Tar was used as a net preservative.

Most of Chapman's shad and herring were sold fresh, but occasionally he had shad split and salted. Generally, however, this was done by the customer, who frequently purchased fish barrels and salt from Chapman in addition to the fish. Since no distinction was made between buck and roe shad, it seems evident that the desirability of shad roe was not appreciated at that time. Not a single reference to fishes other than shad or herring was found in the records.

All fishes were sold by number, rather than by weight. Spring scales were probably not available, and other methods of weighing catches were undoubtedly too laborious. It is interesting to note that, while in most areas fishes are now generally sold by the pound, the Pamunkey and Mattaponi Indians in Virginia still market their catches by the number rather than by weight.

Shad sold for 3¢ to 6¢ each while herring went for about 15¢ per hundred. The market appeared to be far more stable than it is at the present time, for the price of fish varied but little throughout a season.

Slaves were rented as seine haulers for about $4.00 a head, per week. Seine managers received $50.00 a season. Additional wages were paid for Sunday hauling, and no wages were paid for days lost because of bad weather. Also deducted from slave rental were days lost because of sickness or desertion by the seine haulers.

Cash was apparently scarce and many expenses, including labor, were paid in fish. Of interest is the cost some items traded for an equivalent amount of shad. A great coat was worth $4.00, leather apron $.75, jacket and trousers $4.50, pound of coffee $.37½, bushel of peas $1.25, bushel of potatoes $.35, gallon of molasses $1.25, gallon of whiskey $.75, horse $30.00, and one negro woman and one "chile" (part payment) $39.32. Chapman's shrewdness in business affairs is indicated by the following note, "one mair put to your jack $10.00 if mule comes alive,—if not, nothing." A further remark states, "the mair brought forth a horse colt not a mule." There was no mention of value of a horse colt.

Catches and Fishing Effort

Almost one million shad and 116 million herring were caught and sold by Chapman during the period 1814 to 1824 (Table 1). Shad catches ranged from 27,939 in 1820

TABLE 1.—Numbers of American shad and herring caught from the Potomac River and marketed by George Chapman during the period 1814–1824 and the value of these catches.

Year	Shad						Total	Herring	Value
	March 21–31	April 1–10	April 11–20	April 21–30	May 1–10	May 11–20			
1814	—	42,247	69,774	38,774	23,220	6,740	180,755	745,444	$ 5,681.91
1815	212	14,607	91,059	41,150	29,232	1,000	177,260	411,760	8,050.26
1816	—	18,896	16,466	60,156	13,554	4,559	113,631	1,068,932	10,201.85
1817	—	3,577	64,509	24,023	9,653	3,172	104,934	880,578	8,169.03
1818	—	2,817	27,921	22,440	15,675	2,279	71,132	360,922	5,839.75
1819	—	3,674	34,267	12,436	6,311	—	56,688	487,949	3,273.14
1820	—	7,654	12,537	7,748	—	—	27,939	395,166	1,429.50
1821	—	1,658	15,917	26,772	3,909	—	48,256	343,341	1,414.28
1822	1,409	10,783	8,667	18,577	2,885	73	42,394	361,277	1,699.41
1823	—	3,468	7,397	26,204	14,906	—	51,975	442,089	1,472.46
1824	—	6,397	24,640	43,670	5,944	—	80,651	374,328	2,647.66
Total	1,621	115,778	373,154	321,950	125,289	17,823	955,651	115,601,786	$49,879.25

TABLE 2.—Estimated number of hauls made for American shad and herrings by George Chapman's haul seine crew at Chapman's Landing in the Potomac River during the period 1814–1824.

Year	March 21–31	April 1–10	April 11–20	April 21–30	May 1–10	May 11–20	Total
1814	—	22	25	19	10	3	79
1815	1	10	27	17	10	1	66
1816	—	15	18	21	8	2	64
1817	—	4	25	11	9	6	55
1818	—	3	14	12	9	2	40
1819	—	3	16	8	6	—	33
1820	—	5	8	6	—	—	19
1821	—	2	9	11	5	—	27
1822	1	7	5	10	4	1	28
1823	—	4	10	15	7	—	36
1824	—	5	10	18	4	—	37
Total	2	80	167	148	72	15	484

to 180,755 in 1814, while the numbers of herring caught and sold ranged from 343,341 in 1821 to 1,068,932 in 1816. The number of seine hauls estimated to have been made to obtain these catches is indicated in Table 2. Fishing was apparently most intense in 1814, when the number of hauls was estimated at 79, while in 1820 only 19 hauls appeared to have been made.

Estimated shad catch per haul for 10-day periods (Fig. 2) indicates that mean catches increased from about 800 shad per haul in late March to 2250 shad per haul in mid-April. In late May mean catches had declined to about 1200 shad per haul. It is interesting to note the uniform increase and decrease of shad per haul as the fishing season progressed.

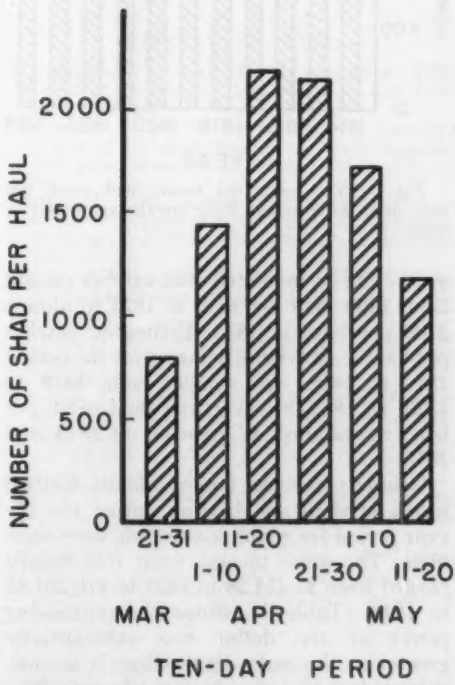

Fig. 2.—The estimated mean shad catch per haul for ten-day periods during the fishing seasons from 1814 to 1824.

Estimated mean catches per haul for each

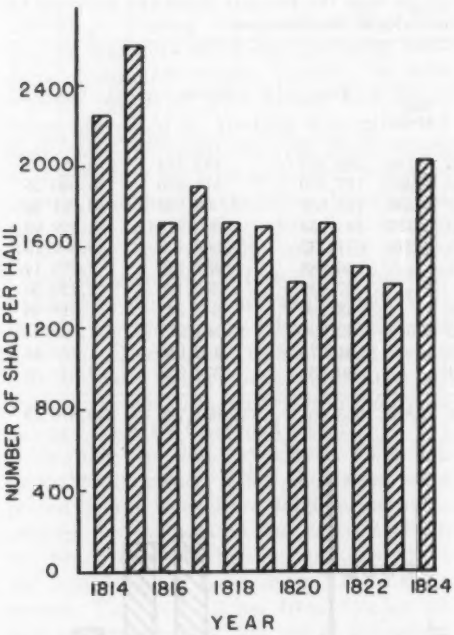

Fig. 3.—The estimated mean shad catch per haul from the Potomac River for the years 1814 to 1824.

year (Fig. 3) indicated that catches ranged from 1400 shad per haul in 1823 to almost 2700 per haul in 1815. Estimated catches per haul were generally larger for the period 1814 to 1818, and smaller from 1819 to 1823. In 1824, however, the shad catch per haul was almost as great as in 1814 and 1815.

George Chapman landed almost $50,000 worth of shad and herring during the 11-year period for which his records were complete. The gross income from this fishery ranged from $1,414.28 in 1821 to $10,201.85 in 1816 (Table 1). Since the purchasing power of the dollar was substantially greater in the early 1800's than it is now, it is evident that the shad and herring fishery was a far more lucrative enterprise than it is at the present time.

Discussion

Haul seines were the only important fishing gear for the capture of shad and herring in the Potomac River during the early 1800's. According to Milner (1876: 335) drift gillnets were introduced between 1835 and 1875 and the first pound nets were not set up until around 1870. Stake gillnets did not come into use until after 1875. Although the total number of haul seine fisheries operating in the Potomac River during the period covered by Chapman's records is not known, there were 150 in 1835 according to Martin (1835:180). It is interesting to note that by 1875 the number of seine fisheries had declined to 33 (Milner, 1876:356). By this time, however, 12 pound nets were being fished and a large number of drift gillnets were in use.

Except for the introduction of power boats and winches and the use of horses to turn the capstans to replace hand labor and use of ice to keep fish fresh, seining is done in almost the same manner today as 140 years ago. Chapman's 350-yard seine was small compared with those used later. Milner (1876:357) stated that most of the haul seines being used in 1875 were about 2000 yards long. He described one, 3200 yards in length. This seine required, in addition to an 8-horsepower engine on the land end and a 14-horsepower engine in the boat, a crew of 60 seine haulers. Most haul seines used at the present time range from 300 to 1000 yards in length and are generally fished by a crew of from four to 10 fishermen.

Shad catches from Chapman's fishery amounted to 955,615 shad for the 11-year period. Assuming that the shad he captured weighed an average of four pounds each (this is a conservative estimate for Martin (1835:180) stated that shad weighed from six to eight pounds) Chapman's catches were equal to about one-third of the catch of shad by all gears from entire Potomac River during the 11-year period from 1946 to 1956. According to Power (1958:195) about 9½ million pounds of shad were taken from the Potomac River during this recent period. If only 100 fisheries were operating on the Potomac River in the early 1800's and they were as successful in the capture of shad as George Chapman, prodigious quantities of shad must have been landed.

Since the population in the 1800's was

far smaller than that at the present time, it is difficult to understand how such large quantities of shad were utilized if present-day eating habits are used for comparison. Most of the shad were salted; therefore spring catches furnished the supply of fish for the entire year. Other species, although used fresh to a limited extent, were generally not eaten. It is probable that most of the fish consumed were either shad or herring. Fish was no doubt relatively more important in the diet during the early 1800's than it is at the present time. Some salted shad were exported to other countries, but the quantities that were shipped out is not known. It seems probable, therefore, that the great quantities of shad captured could all have been utilized.

The demand for herring was not as great as that for shad. Chapman shipped few herring to market. Most were sold locally and their primary use was probably as food for slaves. The numbers of herring listed as caught and sold, therefore, probably reflect more accurately the number of fish sold rather than the number captured. Milner (1876:354) in his visit to the fishery in 1875 was told by Mr. John Chapman that he remembered the time when, "... seine hauls on the shore piled the herring up from the water's edge 12 or 15 feet landward. The men walked or waded knee deep among them, thrusting in their arms to find and select out shad, and allowed the herring to float off at high tide."

It seems curious that not a single reference to fishes other than shad and herring was found in the fish books. There is no doubt that other fishes were captured. Milner (1876:351) described the catch from a seine haul made at Chapman's Point during his visit in 1875 which included shad, two kinds of herring, striped bass, white perch, yellow perch, sunfish, gizzard shad, white catfish, brown bullhead, sucker and also 12 species of small fishes. Since Chapman's meticulous records describe his business transactions to the last half-penny, it appears that only shad and herring were sold. Some of the other fishes captured were used as food for the seine haulers, but most were probably discarded.

There is little doubt, if Chapman's records have been interpreted correctly, that the abundance of shad in the early 1800's was considerably greater than at the present time. These records also suggest that reports by early historians concerning the tremendous quantities of fishes found then may not have been exaggerated. It is hoped that the present effort will stimulate others in the search for and publication of old records that may add perspective to studies of fisheries at the present time.

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Food, Age, Growth, and Morphology of the Blackbanded Sunfish, *Enneacanthus c. chaetodon*, in Smithville Pond, Maryland[1]

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ABSTRACT

A total of 322 specimens of the blackbanded sunfish *Enneacanthus c. chaetodon*, was collected during two separate drainings of Smithville Pond, on the Coastal Plain, Caroline County, Maryland. Ninety, 30 from the November 1955 and 60 from the July 1958 samples, were examined to ascertain age, growth, body proportions, food and sexual dimorphism. Body proportions approached those noted for the recently described southern subspecies *E. c. elizabethae*. No morphological or growth differences were found between males and females in either sample. Lengths of 43–53 mm were attained in about four years. Wide differences occurred, between samples, in the calculated lengths for ages 1 and 2 while those for ages 3 and 4 were more similar. Further investigation will determine whether these data exhibit populations which reflect extremes of growth-environment interplay or an unreliability in the scale method of determining age and growth for this species. Chironomids (summer) and caddis fly larvae (fall) were prominent food items.

The biology of the diminutive blackbanded sunfish, *Enneacanthus chaetodon chaetodon* (Baird), which ranges in coastwise streams from New Jersey to Florida, is little known. Many observations have been made on aquarium specimens (Dean 1916–23). However, only Innes (1945: 104–5) gave data on sizes and ages for such specimens. Smith (1907:237) commented that natural populations of *E. c. chaetodon* spawn in March in North Carolina. Milewski (1910:727) found aquarium specimens nesting in May and June. The food of the southern subspecies *E. c. elizabethae* is documented by Chable (1947:96) and Reid (1950b:239). The ranges of both subspecies are well marked in the literature. Blair, et al. (1957:172), Eddy (1959:187), Evermann (1916:80), Fowler (1906:285, 1921: 67, 1945:144), Freeman (1952:269), Jordan (1929:150), Jordan and Evermann (1896: 994–5), Mansueti (1951:302), Pratt (1923: 117), Smith (1907:237), Truitt, Bean and Fowler (1929:73) and Welsch (1916:56) cite *E. c. chaetodon* localities while Bailey (1941:1–7) described and Bailey and Hubbs (1949:34), Carr (1937:85), Chable (1947: 22–5), Reid (1950a:22–5, b:239) and Wright (1923:410, 1926:77–95) discussed *E. c. elizabethae* distributions.

Two complete drainings of Smithville Pond, Caroline County, a pond on the Maryland-Delaware state line, yielded two samples of *E. c. chaetodon* which were used for age, growth, food and morphology studies. Mansueti (1951:302) had previously noted the presence of *E. c. chaetodon* in Smithville Pond as an associate of the darter *Etheostoma* (=*Hololepis*) *fusiforme*. Smithville Pond was first drained November 16, 1955 and yielded 44 specimens 42–52 mm in standard length. During a second draining on July 28, 1958, 322 additional specimens 16.5–50 mm in standard length (Fig. 1) were obtained. A total of 90 specimens, 30 from the November 1955 and 60 from the July 1958 sample were studied in detail.

[1] Contribution No. 177, Maryland Department of Research and Education, Solomons, Maryland.

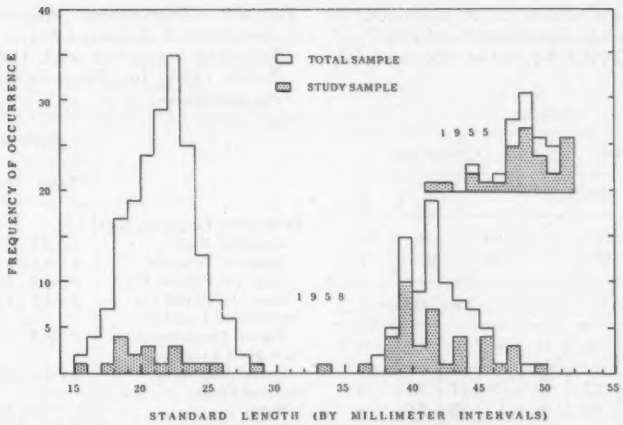

Fig. 1.—Frequency distribution of the blackbanded sunfish, *Enneacanthus c. chaetodon*, by one mm intervals as collected from Smithville Pond, Maryland, November, 1955 and July, 1958.

Habitat Description

Smithville Pond (elevation 30 feet) is a long, slender Coastal Plain impoundment of some 43 acres situated on the Maryland-Delaware state line, six miles north of Federalsburg, Caroline County, Maryland. It was formed by damming a tributary of Marshy Hope Creek some 80 years ago. The inflow drainage (62 sq. mi.) is entirely within Delaware. The outflow is to the west and part of the Nanticoke River watershed which flows into Chesapeake Bay. The maximum depth is about eight feet, with an average of three feet. The shore is partly wooded, partly cultivated fields. Chemically, the pond water is soft (13 ppm total alkalinity) and its pH is about 7.1. The water is a brownish color, evidence of its swamp origin. Secchi-disk readings of three feet have been obtained in August. The water was turbid from high plankton blooms.

Methods

Standard methods of counts and body measurements follow Hubbs and Lagler (1958:19–26). Counts were made of the dorsal spines, dorsal rays, anal spines, pectoral rays, pelvic rays, lateral line scales, scales above the lateral line, and scales below the lateral line for each sex. Measurements of standard length, total length, head length, caudal peduncle length, pectoral fin length, highest dorsal spine, highest anal, lowest anal, predorsal distance, snout length, head width, body width, eye diameter, and upper jaw length. Observations of the genital area were made to ascertain a sexual dimorphic (Anon. 1910:55) character of papilla size or shape, to no avail.

The position of the pectoral fin ending in relation to the genital opening, a secondary character often used in other species (Schwartz and Norvell, 1958:314–5), was also noted for possible sexual dimorphism; however, the fin in all cases ended either on, slightly before or behind the third anal spine. This difference was so small that its value was not considered adequate for sex discrimination. Egg condition was noted since Smith (1907:237) found *E. c. chaetodon* spawning in March in North Carolina. Generally, the eggs were small or absent in the July sample while in November they averaged 0.3 mm. Abbott (1884:1255) noted in the spring of 1881 that females were heavy with immature eggs.

Morphology

E. c. chaetodon from Smithville pond was found to possess 10 dorsal spines, 11 dorsal rays, three anal spines, 12 anal rays, 9–10 pectoral rays, five pelvic rays, about 27 lateral line scales (range 23–30), five scales

TABLE 1.—Meristic values of 90 specimens of *Enneacanthus c. chaetodon* from Smithville Pond, Maryland, collected November 1955 and July 1958

Character									
	Dorsal Spines			Dorsal Rays					
N	9	10	11	11	12	13			
30[1]	3	26	1	24	6	—			
60[2]	4	55	1	43	16	1			
	Anal Rays				Pectoral Rays				
N	10	11	12	13	8	9	10	11	
30	—	2	27	1	—	17	11	2	
60	1	5	46	8	1	26	33	—	
	Scales above Lateral Line				Scales below Lateral Line				
	4	5	6	X	9	10	11	12	X
30	—	28	—	2	—	3	18	5	4
60	1	40	1	18	1	17	20	1	21
	Pelvic Rays								
	4		5		X				
30	—		29		1				
60	1		59		—				
	Lateral Line Scales								
	23	24	25	26	27	28	29	30	X
30	—	—	—	—	8	9	7	—	6
60	1	1	10	6	14	6	5	2	15

X—Character was too badly damaged to permit a count or the specimen was too small.

above the lateral line and 10–11 scales below the lateral line (Table 1). Only anal spine and pectoral fin ray counts varied least throughout the specimens examined. Following Bailey's (1941, Table II:4) proportionate measurement comparison for *E. c. elizabethae*, note that the ranges and ratios (Table 2) of *E. c. chaetodon* from Maryland overlap those of *E. c. elizabethae* from Florida. Bailey (1941:2) states that the diagnostic characters for *E. c. chaetodon* do not approach *elizabethae*, which is generally the case herein.

Between sexes, the two samples were so similar that no distinction was made when many of the ratios, determined in Table 2,

TABLE 2.—Proportional measurements of 90 specimens of *Enneacanthus c. chaetodon* from Maryland compared with those reported by Bailey (1941) for *Enneacanthus c. elizabethae*, six specimens.

	Maryland		Florida	
	Range	Mean	Range	Mean
In Standard Length (in mm)				
Length of Head	2.6–2.9	2.65	2.65–2.8	2.62
Length of Peduncle	4.4–6.4	5.97	4.8–5.8	5.30
Length of Pectoral Fin	3.2–4.2	3.49	3.3–3.6	3.44[1]
Length of Caudal Fin	2.8–3.5	3.14	2.7–3.0	2.86[2]
In Predorsal Distance:				
Highest Dorsal Spine	1.9–2.3	2.13	2.3–2.7	2.57
In Highest Anal Spine:				
Lowest Anal Spine	1.7–3.0	2.06	1.95–2.6	2.14
In Head Length				
Width	1.8–2.3	2.03	2.0–2.15	2.06
Length of Orbit	2.5–3.4	3.00	2.8–3.25	3.03
Length of Snout	3.4–5.0	3.89	4.0–4.3	4.11
Length of Upper Jaw	3.1–4.1	3.53	2.35–2.65	3.78
Standard Length				
July, 1958	16.5–50.5	36.86	—	—
November, 1955	42.2–52.7	49.27	—	—
Bailey, 1941	—	—	32.0–46.0	38.6

[1] Five specimens.
[2] Four specimens.

were plotted (Fig. 2). Generally the 1955 and 1958 samples complimented each other by filling gaps in the other's data. The 1955 sample helped fill the upper ends of the data; however, a definite gap of information was evident between 27 and 40 mm standard length. The November study sample was composed of eight males and 22 females while the 1958 sample was composed of 31 males, 28 females and one whose sex could not be determined.

Age and Growth

Sorting out the specimens visually by one-half inch intervals suggested four age groups which were then sampled by means of a table of random numbers. Fig. 1 illustrates the total number of specimens by one mm (standard length) intervals and the number within each interval which were studied. Since these length frequencies suggested only three age groups, with one age group apparently missing between 30–36 mm, some other more reliable method of aging the blackbanded sunfish was desirous. Although extreme care must be exercised in reading *E. c. chaetodon* scales, annuli were ascertainable and proved a ready means of aging this species. Annuli consisted of spo-

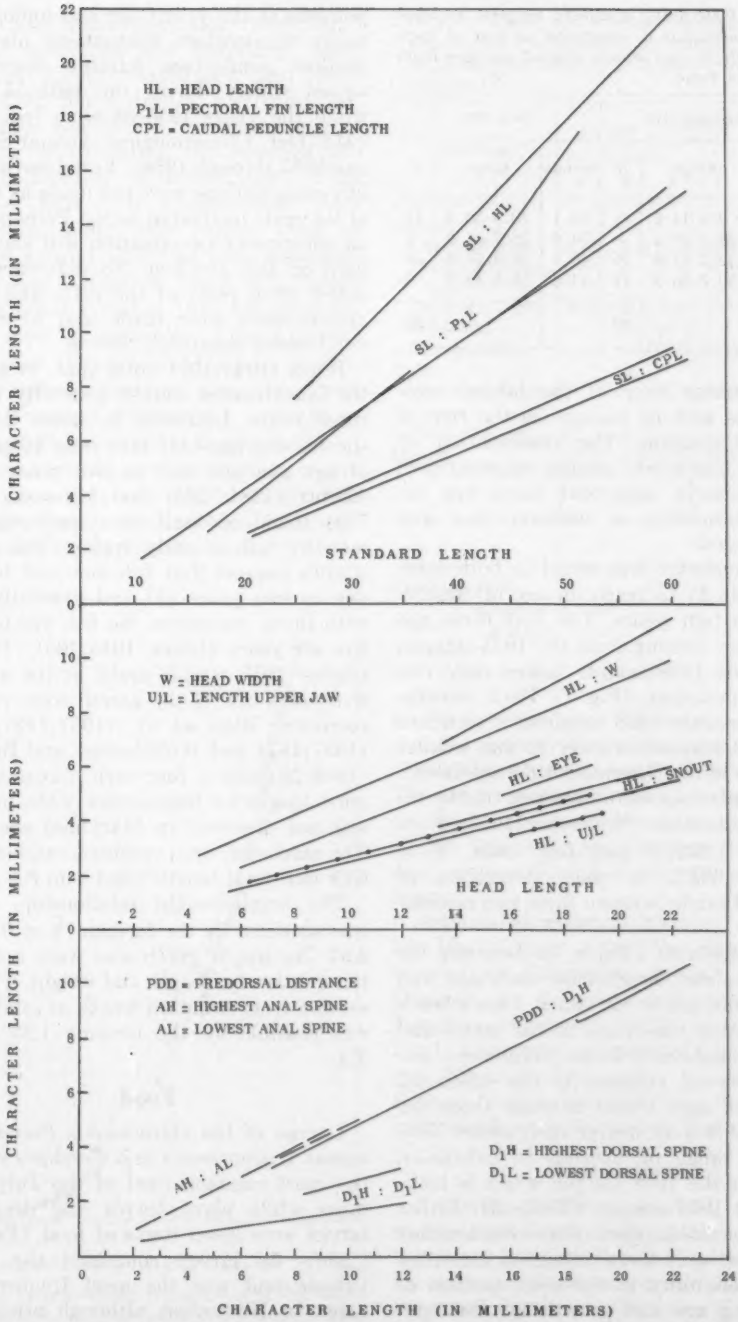

FIG. 2.—Ten morphometric character ratios from the 90 specimens of *Enneacanthus c. chaetodon* examined and collected November, 1955 (shorter line in each case) and July, 1958.

TABLE 3.—Calculated standard lengths (in mm) for *Enneacanthus c. chaetodon* at end of each year of life in two widely spaced samples from Smithville Pond.

Age	November, 1955			July, 1958		
	Average	Range	*N*	Average	Range	*N*
1	10.4	9.9–11.6	—	25.1	20.9–30.3	11
2	27.2	25.9–29.2	—	34.6	26.7–41.8	5
3	45.1	42.2–47.9	19	40.7	32.8–51.0	31
4	53.7	50.7–56.0	11	43.6	35.6–49.2	9
			30			56

radic crossings over of the lateral scale margins as well as changes in the rate of circulae formation. The combination of these two characters usually substantiated the annulus. In only four cases was the circulae formation so uniform that any doubt existed.

E. c. chaetodon was noted in both samples (Table 3) to reach an age of slightly more than four years. The first three age groups were missing from the 1955 sample, whereas the 1958 sample lacked only two year old specimens. (Fig. 1). Back calculation of the July 1958 specimen's standard lengths were approximately 10 mm smaller than those of the November 1955 specimens. Back calculations were obtained by the regression formulas: November 1955, $\hat{Y} = -11.0 + 1.2721X$ and July 1958, $\hat{Y} = 15.4 + 0.683X$. A good correlation of $r = 0.8679$ exists between these two calculations.

The differences (Table 3) between the mean calculated lengths for each age and sample could not be explained, even when a reexamination was made of the scales and back calculations. Wide differences occurred, between samples, in the calculated lengths for ages 1 and 2 while those for ages 3 and 4 were nearer each other. Note the wide range of overlap in calculated lengths for the 1958 sample which is lacking in the 1955 sample (Table 3). Either these data exhibit populations which reflect extremes of growth-environment interplay or an unreliability in the scale method of determining age and growth for this species. The former is probably the truer hypothesis as the yearly air and undoubtedly water temperature fluctuations about the shallow pond (see habitat description) varied widely during the 1951–55 period while the years 1955–58 were less erratic (Md.-Del. Climatological Annual Summaries 1955 through 1958). Vertebrae and otolith examinations were not made as a check of the scale method of aging. Perhaps, these on subsequent examination will shed more light on this problem. No differences were noted when plots of the male and female growth data were made and hence were not treated separately herein.

Innes (1945:105) notes that, in aquaria, the blackbanded sunfish generally live for three years. Likewise, he notes that this species was one-half inch long at one year of age and one inch at two years of age. Abbott (1884:1255) and Milewski (1911: 759) found one-half inch specimens common by fall or early spring. The present studies suggest that fish one inch long are one to two years old and generally agree with Innes' statement. No fish was found to live six years (Innes, 1945:105). The November 1955 sample could, at the most, be five years old, if the annuli were read incorrectly. Blair et al. (1957:172), Eddy (1957:187) and Wolfsheimer and Borgeson (1958:53) cite a four inch maximum (100 mm) length for this species. This, however, was not observed in Maryland specimens. The maximum sized specimen examined was 68.9 mm total length (52.1 mm S.L.).

The length-weight relationship, Fig. 3, was obtained by the formula $\hat{Y} = 0.19X - 3.97$. No major differences were noted between sexes for length and weight. The conversion from standard length to total length was possible by the formula 1.32 S.L. = T.L.

Food

Larvae of the chironomids *Pseudochironomus* (*richardsoni*) and *Tendipes* sp. were the most common food of the July specimens while plant leaves and dragon fly larvae were lesser items of food (Table 4). Caddis fly larvae composed the greater volume and was the most frequent food eaten in November, although other items such as chironomids, gammarids (crus-

taceans) and filamentous algae were found in lesser quantities and frequency. Generally, as Chable (1947:96) and Reid (1950a:239) found for *E. c. elizabethae*, chironomids constituted the most frequent food item eaten during the summer. Although gammarids constituted part of the November food of *E. c. chaetodon*, other crustaceans, along with insects such as caddis fly, coleoptera larvae, ephemeroptera, odonata and tricoptera which were noted for *elizabethae* (Chable, 1947:96) were absent as food of *chaetodon*. Abbott (1884: 1255) noted chironomids, *Cyclops quadricornis*, daphnia, diatoms, desmids, algae, and the rhizopod *Centropyxis aculeata* as the food of 12 specimens of *E. chaetodon*. Of the 90 stomachs examined, 58 were empty (65%), eight were full and 24 partly full. It appears that *E. c. chaetodon*, in Maryland prefers weedy situations and tends to

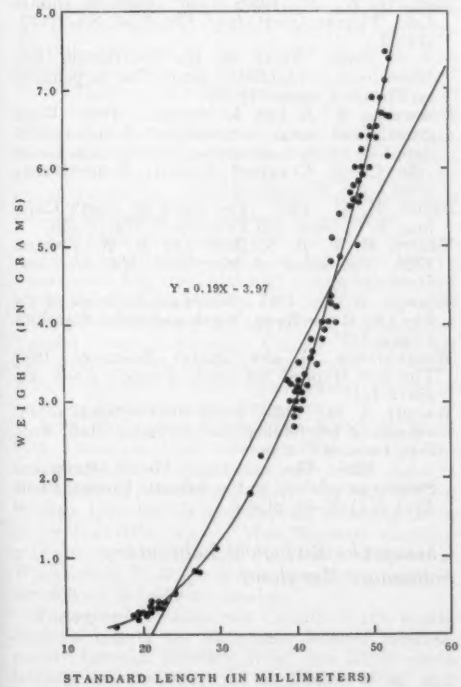

FIG. 3.—Length-weight relationship of the blackbanded sunfish, *Enneacanthus c. chaetodon*, from Smithville Pond, Maryland.

TABLE 4.—Food and stomach contents of *Enneacanthus c. chaetodon*, by sample, expressed as percentage frequency of occurrence (F) and volume (V).

Food Item	July 1958		November 1955		Total	
	F	*V*	*F*	*V*	*F*	*V*
Animal						
Chironomidae	75.0	73.3	12.5	12.5	59.3	58.1
Caddis Fly Larvae	—	—	37.5	37.5	9.3	9.3
Dragon Fly Larvae	8.3	8.3	—	—	6.3	6.3
Gammarids	—	—	12.5	12.5	3.1	3.2
Plant						
Filamentous Algae	—	—	25.0	25.0	6.3	6.3
Plant Leaves	16.7	8.9	—	—	12.5	6.7
Debris	2.0	9.5	12.5	12.5	18.7	10.0
		100.0		100.0		100.0
	N		*N*		*N*	
Stomach Full	3		—		8	
" Empty	36		22		58	
" Partly Full	16		8		24	

be a bottom feeder at the two seasons where samples were available. Perhaps as Abbott (1889:257) suggests, it is a nocturnal feeder. This might account for the large number of specimens examined whose stomachs were empty. The study specimens, on each occasion, were collected during the afternoon hours.

Acknowledgments:—Thanks are due Mr. Harold Elser of the Department of Research and Education, Inland Resources Division, for historical and ecological information concerning Smithville Pond, and Dr. L. Curry, Department of Biology, Central Michigan University, for determinations and comments concerning the chironomids which were prominent food items.

Conclusions

Following standard methods of counts and measurements, body proportions of the specimens from Smithville Pond were found to approach those noted for the recently described southern subspecies *E. c. elizabethae*. Maryland specimens of *E. c. chaeto-*

don were found to grow to a length of between 43–53 mm standard length in four years. None were found to live longer than four years although aquarium specimens have been known to live to six years. No morphological or growth differences could be found to delineate males from females in either sample. The food of *E. c. chaetodon* in July was primarily the chironomid larvae of *Pseudochironomus* and *Tendipes*. Caddis fly larvae were the most frequent November food. Generally, the blackbanded sunfish, by food preference, seems to prefer weedy situations where it feeds on bottom and plant foods, perhaps at night.

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Notes and Comments

Benthic Shoal Water Invertebrates from Tidewaters of Somerset County, Maryland[1]

ABSTRACT

Forty-one invertebrate species were collected during two surveys of the soft-shelled clam, *Mya arenaria*, in Somerset County waters of the Chesapeake Bay area. Quantitative samples taken with the hydraulic clam dredge were limited to bottoms in waters between 3 and 9 feet deep. Major bottom types, water temperatures, salinities, and dominant species in each of the twelve sampled areas are presented. The common synapta, *Leptosynapta inhaerens*, the ornate worm, *Amphitrite ornata*, and the stout razor clam, *Tagelus plebius*, were the most abundant and widely distributed species.

Introduction:—Shallow water areas of Somerset County were extensively surveyed for commercial quantities of the soft-shelled clam, *Mya arenaria*, between 22 October and 11 December 1957 (Manning and Pfitzenmeyer 1958:1–6), and again between 25 August and 2 September 1959 (Pfitzenmeyer 1960:66–8). As a contribution to the knowledge of the invertebrate fauna of this region, a quantitative species list of the benthic organisms collected on these two surveys along with limited ecological observations is presented.

Only a few reports have been published concerning the invertebrate fauna of this part of the Chesapeake Bay area. Although it remains the most complete biological study of the Bay, Cowle's (1930:277–381) survey did not include the waters of Tangier Sound or Somerset County. Recently, Allen (1954a:56–65, b:92–4, 1955a:83–7, b:87–90, 1958:49–51) has reported upon several species of mollusks from this particular region.

Acknowledgments are due Mr. Joseph H. Manning, Department of Tidewater Fisheries for encouragement with the problem, and to Mr. John L. E. Edgar, Jr., student, Antioch College, Yellow Springs, Ohio for his assistance in obtaining much of the field data; also to Miss Margaret Simpson, graduate student, Catholic University of America, Washington, D. C. for aid in identifying many of the difficult polychaete annelids.

Topography:—Somerset County is the southernmost county of Maryland, located approximately between parallels 37°55′ and 38°15′ north latitude and between the meridians 75°35′ and 76°05′ west longitude. It is situated on the eastern shore of the Chesapeake Bay, making up part of the Coastal Plain province of Maryland and of the Atlantic Coast. As typical of most Atlantic coastal plain provinces, the numerous small bays, rivers, and creeks which indent the shore line are almost entirely bordered by tidal marches. The net outward flow of fresh water is very small due to the limited watershed.

In Somerset County there are about 85,000 acres of shoal water within the 12-foot contour. These depths are in the operational range of the hydraulic clam dredge. This includes the area along the main shore, and the shoal areas surrounding South Marsh Island and Smith Island. These islands, made up almost entirely of tidal marsh, are located about five miles offshore and form the western border between Tangier Sound and the Chesapeake Bay proper.

Tangier Sound (Fig. 1), which extends the entire length of Somerset County, is noted for the marked faunal changes that distinguish it from waters of the upper Bay. Its extensive shallow water areas help to produce relatively high water temperatures in summer. Likewise, salinities are higher; a minimum of 11 ppt and a maximum of 23 ppt have been recorded by the Chesapeake Bay Institute. The mean tidal range of the Sound is about two feet and essentially follows the pattern of the remaining Bay area.

Methods and Procedure:—Since the sampling area was large, an intensive study of all portions was not possible within the sampling periods. The locale of most sampling, therefore, was determined by areas where bottom type and protection from wind favored the soft-shelled clam, or where their siphon holes were seen in the bottom. No samples were taken where commercial clam dredging would ordinarily be prohibited, such as from public and private oyster grounds, polluted areas, or commercially developed shorelines.

The effectiveness of the hydraulic clam dredge for use as a sampling apparatus has been reported by Manning (1960:61–7). The design of the boat and dredge limit bottom sampling to depths between three to 12 feet of water. A three-eighth inch mesh wire conveyor belt was used on the dredge; therefore, many organisms were lost which would pass through this size screening. Some smaller organisms were found in the samples as they remained attached to larger shells, vegetation, or other organisms.

A definite number of quantitative samples were taken throughout the 12 sampling areas (Fig. 1). In some instances where conditions appeared to be

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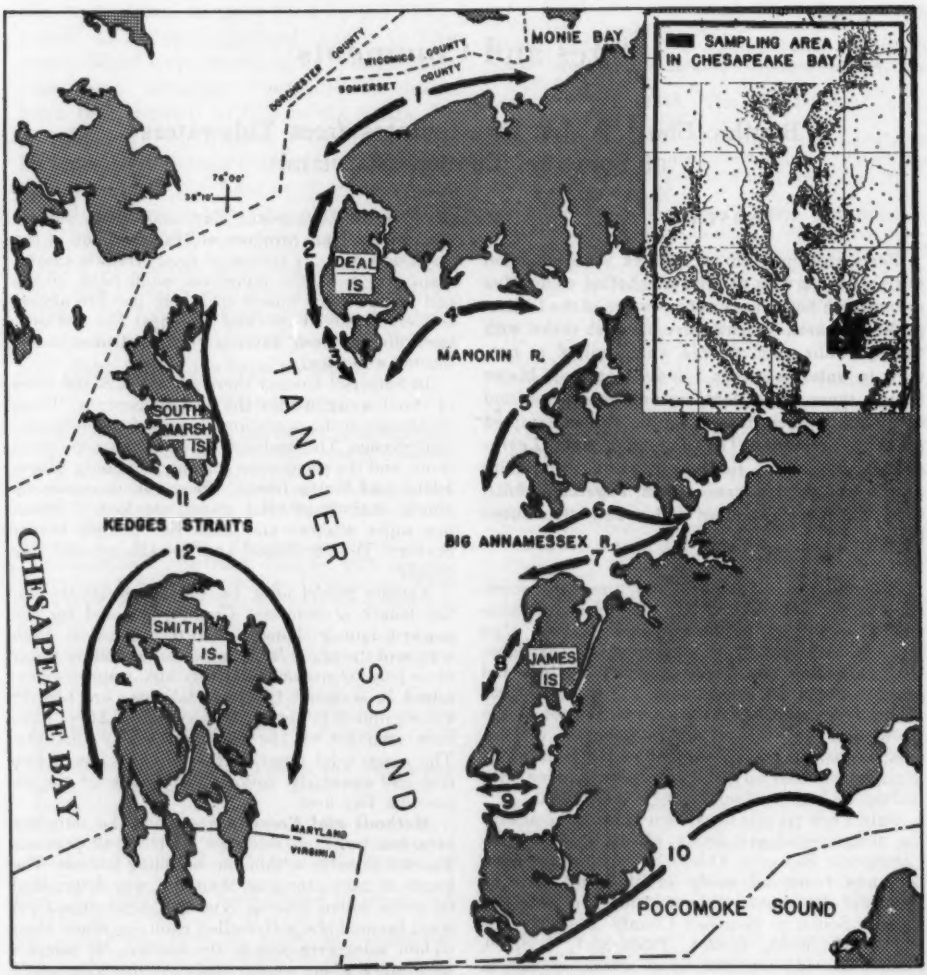

Fig. 1.—Numbers with arrows on either side on map represent locations of sampling areas in which samples of invertebrates were collected within tidewater Somerset County, Maryland.

favorable for the production of soft-shelled clams, a large number of samples were taken to obtain a more accurate estimate of the population. In other areas only a minimum number of samples were made. Each quantitative sample consisted of 30 cubic feet of bottom, 2½ feet wide, by 8 feet in length, and 1½ feet deep.

The minimum and maximum number of organisms occurring in all the quantitative samples taken in each of the 12 areas are given in Table 1 for the first survey and Table 2 for the second survey. The numbers one, two, and three appearing in these tables are frequency groupings assigned to the number of organisms per 30 cubic foot sample. One to 10 organisms were assigned the value one; 11 to 50 organisms were assigned the value two; and over 51 organisms were assigned the value three. In several locations some species were observed either before or after the quantitative sample was taken. These are indicated in the tables by a plus (+) sign as being present at that location but not taken in the quantitative sample. As the sample was made, the species which could not be identified were collected and preserved. The remaining organisms were counted as they appeared on the endless conveyor belt and returned to the water.

TABLE 1.—Minimum and maximum number of species of invertebrates per 30 cubic foot sample in each of the 12 sampling areas for the period 22 October to 1 December 1957, tidewater Somerset County, Maryland. + = present but not in sample; 0 = absent; 1 = 1–10 organisms; 2 = 11–50 organisms; 3 = 51 organisms or more.

Species	Area											
	1	2	3	4	5	6	7	8	9	10	11	12
Porifera												
Suberites sp.	—	—	—	+	+	—	—	—	—	—	+	—
Microciona sp.	—	—	—	—	—	—	—	—	—	—	—	+
Nemertea												
Cerebratulus sp.	—	—	—	0–1	—	0–1	0–1	—	—	0–1	—	—
Annelida												
Neanthes succinea	—	—	—	0–1	—	—	—	—	—	—	—	0–1
Diopatra cupraea	—	—	—	—	—	1–3	—	—	—	—	—	0–2
Glycera dibranchiata	—	0–2	0–1	0–1	0–1	0–1	—	—	0–1	1–2	0–1	0–2
Glycera sp.	—	0–1	—	—	—	—	—	—	—	—	—	—
Amphitrite ornata	0–3	0–3	0–2	0–1	0–2	1–2	0–2	—	0–2	1–3	0–2	0–2
Pista palmata	—	—	—	1–3	0–1	1–1	0–2	—	—	—	—	—
Pectinaria gouldi	0–1	0–2	0–2	0–1	0–1	0–2	—	—	0–1	1–2	0–1	0–2
Clymenella torquata	—	0–2	0–1	0–2	0–1	0–3	0–1	—	—	—	—	0–1
Potamilla sp.	—	—	—	0–2	0–1	0–2	0–1	—	—	—	—	—
Sabellaria vulgaris	—	0–2	—	—	—	—	—	—	—	—	—	—
Mollusca												
Crepidula convexa	—	0–2	—	0–1	—	—	—	—	—	—	—	+
Crepidula fornicata	—	—	—	—	—	—	—	—	—	—	—	+
Urosalpinx cinerea	—	—	—	—	+	0–1	—	—	—	0–1	—	+
Eupleura caudata	—	—	—	—	—	—	—	—	—	—	—	0–1
Nassarius vibex	—	0–1	—	0–1	0–1	0–1	0–1	—	—	—	0–1	0–2
Nassarius obsoletus	—	1–2	0–2	0–1	0–1	0–2	0–1	—	1–1	0–2	0–1	0–2
Amygdalum papyria	—	0–1	—	0–1	—	—	0–1	—	—	—	—	—
Aligena elevata	—	—	—	—	—	—	—	—	—	—	—	+
Crassostrea virginica	—	0–1	0–1	—	+	—	0–1	—	—	0–2	—	0–1
Laevicardium mortoni	—	0–1	0–1	0–1	—	0–1	0–1	—	0–1	—	—	—
Mercenaria mercenaria	—	—	—	—	—	0–1	0–1	—	0–1	0–2	—	—
Petricola pholadiformis	—	0–2	—	—	—	—	—	—	—	—	0–1	0–3
Gemma gemma	+	0–2	—	—	—	—	—	—	—	—	—	—
Macoma balthica	0–1	0–1	0–1	0–1	—	—	—	—	—	0–2	0–1	0–2
Macoma phenax	—	—	—	—	—	—	—	—	—	—	—	0–1
Tagelus plebeius	0–2	1–3	0–1	0–3	0–1	1–3	0–2	—	0–2	1–3	0–1	0–1
Tagelus divisus	—	—	—	—	—	—	—	—	0–1	0–1	—	0–1
Ensis directus	—	0–1	—	—	—	—	—	—	0–1	+	0–1	—
Mulinia lateralis	—	0–2	0–2	0–1	0–1	0–1	0–1	—	0–1	1–2	0–1	0–2
Mya arenaria	—	0–2	0–1	0–1	0–1	0–1	0–1	—	0–1	0–1	0–1	0–1
Cyrtopleura costata	—	—	—	—	—	—	—	—	—	—	0–1	0–1
Barnea truncata	—	0–1	—	—	—	—	—	—	—	—	0–1	0–1
Lyonsia hyalina	—	0–1	0–1	0–1	—	—	—	—	—	0–1	0–1	0–1
Echinoderma												
Leptosynapta inhaerens	0–1	0–2	1–2	0–1	0–2	1–2	0–2	—	0–2	1–3	0–2	0–2
Tunicata												
Molgula manhattensis	0–1	0–1	0–3	0–1	—	0–2	—	—	—	0–1	—	0–1
Total Species	7	23	14	21	15	18	15	—	12	17	16	27

Only surface salinities and temperatures were recorded in view of the shallowness of the water sampled (maximum of 9 feet). The bottom types given in Table 3 were those found most common throughout each of the 12 sampling areas. A mechanical analysis of the bottom types was not performed since it was not necessary to fulfill the primary objective of the survey—an inventory of the soft-shelled clam population.

Results and Discussion:—When compared with areas of the upper bay which have been sampled with the hydraulic dredge, probably the most significant difference in the invertebrate fauna was the appearance of organisms associated with higher

TABLE 2.—Minimum and maximum number of species of invertebrates per 30 cubic foot sample in each of the 12 sampling areas for the period 25 August to 2 September 1959, tidewater Somerset County, Maryland. + = present but not in sample; 0 = absent; 1 = 1–10 organisms; 2 = 11–50 organisms; 3 = 51 organisms or more.

Species	Area											
	1	2	3	4	5	6	7	8	9	10	11	12
Porifera												
Suberites sp.	—	—	—	+	—	—	—	—	—	—	—	—
Microciona sp.	—	—	—	—	+	—	—	—	—	—	—	—
Nemertea												
Cerebratulus sp.	0–1	0–1	—	0–1	—	—	0–1	—	—	0–1	—	—
Annelida												
Neanthes succinea	—	—	—	0–1	—	—	—	—	—	—	—	—
Diopatra cupraea	—	—	—	—	—	—	—	—	—	0–1	—	—
Drilonereis longa	—	—	—	0–1	—	—	—	—	—	0–1	—	—
Glycera dibranchiata	0–2	0–1	1–1	1–1	0–1	1–1	1–1	1–1	1–1	1–2	0–1	0–1
Amphitrite ornata	0–1	0–3	+	1–1	1–1	0–1	1–2	1–1	0–1	0–1	0–2	0–1
Terebellides sp.	—	—	—	—	—	—	—	—	0–1	—	—	—
Pectinaria gouldi	—	1–1	0–1	0–1	0–1	0–1	0–1	0–1	0–1	0–1	0–2	0–1
Clymenella torquata	—	—	—	0–1	0–1	0–1	0–1	—	0–2	0–2	—	—
Phascolion strombi	—	—	0–1	0–2	—	—	0–2	—	0–1	0–2	—	—
Mollusca												
Crepidula fornicata	—	—	—	—	—	—	—	—	—	0–1	—	0–1
Urosalpinx cinerea	—	—	—	—	—	+	—	—	—	—	—	—
Eupleura caudata	—	—	—	—	—	0–1	—	—	0–1	—	—	0–1
Nassarius vibex	—	0–1	0–1	0–1	0–1	0–1	0–1	—	0–1	0–1	0–1	—
Nassarius obsoletus	—	0–1	0–1	1–1	0–1	0–1	0–1	—	1–1	0–1	1–1	0–1
Amygdalum papyria	—	—	—	—	—	—	0–1	—	—	—	—	—
Crassostrea virginica	—	—	—	—	0–1	—	—	—	—	0–1	0–1	—
Laevicardium mortoni	—	—	—	0–1	0–1	—	0–1	—	+	0–1	0–1	0–1
Mercenaria mercenaria	—	—	—	—	—	—	—	—	0–1	0–1	—	—
Petricola pholadiformis	—	—	—	—	—	—	—	—	0–1	—	0–1	0–3
Macoma balthica	—	—	0–1	0–1	0–1	—	—	—	—	0–1	+	0–1
Tagelus plebeius	1–3	0–2	0–1	1–1	1–1	0–1	0–2	0–1	0–1	1–3	0–1	0–1
Ensis directus	0–1	0–1	—	—	—	—	—	—	—	0–1	0–1	—
Mulinia lateralis	—	0–1	0–1	0–1	0–1	—	—	—	0–1	0–1	0–1	—
Mya arenaria	+	0–1	0–1	0–1	0–2	0–1	0–1	0–1	0–1	0–1	0–2	0–2
Cyrtopleura costata	—	—	—	—	—	—	—	—	—	0–1	—	—
Barnea truncata	—	—	0–1	—	—	—	—	—	—	—	—	—
Lyonsia hyalina	—	—	—	—	—	—	—	0–1	—	—	—	—
Echinoderma												
Leptosynapta inhaerens	0–1	0–1	0–1	0–1	1–2	1–1	1–3	0–1	0–2	0–1	0–1	0–1
Tunicata												
Molgula manhattensis	—	0–1	0–1	0–1	0–1	0–1	0–1	—	0–1	0–1	0–1	0–1
Total Species	7	12	13	18	15	12	14	7	17	22	15	13

salinities of the lower bay. Polychaete annelids, especially the ornate worm *Amphitrite ornata* and a holothurian, the common synapta, *Leptosynapta inhaerens* were very abundant and widely distributed throughout the areas sampled. This association was often present in soft bottoms near drainage from surrounding marshes where in most instances other organisms were not collected. Many animals besides those mentioned above, which are usually associated with higher salinities of the bay, were present: *Aligena elevata, Tagelus divisus,* and *Cyrtopleura costata* were not as abundant as *Lyonsia hyalina, Mercenaria mercenaria, Urosalpinx cinerea, Eupleura caudata, Barnea truncata, Diopatra* sp., and *Cerebratulus* sp.

The great quantities of detritus and other organic matter, produced by the marshes which make up nearly the entire shore of the sampled area, are deposited in large amounts in the adjacent shoal water areas. Bader (1954:44) has shown that where organic content exceeds 3%, the products of decomposition, with the resulting decline in available oxygen, may become the limiting variables in controlling pelecypod populations. This may also contribute to the reduction of other species, especially during periods of high temperature when the oxy-

TABLE 3.—Sampling area data with dominant invertebrates from tidewater in Somerset County, Maryland.

Area	Water Depth Sampled (ft.)	Major Bottom Type	Surface Temp. °C.		Surface Salinity ‰		Dominant Organisms	
			1957	1959	1957	1959	1957	1959
1. Monie Bay	3–6	Silt inshore, mud to sandy mud offshore.	15.0	30.2	20.6	10.2	*Amphitrite* *Tagelus*	*Tagelus* *Glycera*
2. Deal Island	3–5	Muddy sand to sand over fibrous peat	—	29.5	20.7	14.6	*Tagelus* *Amphitrite* *Nassarius*	*Amphitrite* *Tagelus* *Pectinaria*
3. Little Deal Island	3–6	Sand and muddy sand over clay	15.3	29.5	—	15.1	*Leptosynapta* *Amphitrite*	*Glycera* *Nassarius*
4. Manokin River North	3–6	Muddy sand and sandy mud with mud inshore	—	30.0	19.5	14.6	*Tagelus* *Pista* —	*Tagelus* *Amphitrite* *Nassarius*
5. Manokin River South	3–5	Sandy mud to sand over coarse gravel occasionally.	14.5	32.0	19.9	16.0	*Leptosyndpta* *Amphitrite*	*Leptosynapta* *Amphitrite* *Glycera*
6. Big Annemessex River North	3–7	Sand to muddy sand with mud inshore	10.1	29.5	20.1	16.1	*Tagelus* *Amphitrite* *Leptosynapta*	*Leptosynapta* *Glycera* —
7. Big Annemessex River South	4–6	Sand to sandy mud over clay	—	30.0	—	15.9	*Tagelus* *Amphitrite* *Leptosynapta*	*Leptosynapta* *Amphitrite* *Glycera*
8. James Island	5–7	Sandy clay over hard clay	—	31.5	—	17.3	— —	*Amphitrite* *Glycera*
9. Little Annemessex River	3–7	Mud to sandy mud to hard clay	—	29.5	—	18.0	*Tagelus* *Amphitrite* *Leptosynapta*	*Nassarius* *Glycera* —
10. Pocomoke Sound	3–8	Soft mud inshore to sandy mud. Some clay and muddy sand areas.	8.0	28.8	17.9	16.7	*Tagelus* *Amphitrite* *Leptosynapta*	*Tagelus* *Glycera* —
11. South Marsh Island	3–9	Soft mud to sandy mud over clay. Sand offshore.	—	29.7	19.9	15.8	*Amphitrite* *Leptosynapta*	*Nassarius* *Pectinaria*
12. Smith Island	3–9	Soft mud inshore. Clay to sand on exposed shores.	11.4	30 0	20.6	17.0	*Amphitrite* *Leptosynapta*	*Amphitrite* *Glycera* *Tagelus*

gen demand is greater. Temperatures above 30.0°C were not uncommon in these shoal water areas during the second survey in August 1959 (Table 3).

Sanders (1956:399–403), in a study of the bottom communities of Long Island Sound, found that selective and nonselective deposit-feeding organisms dominated the finer sediments while suspension feeders were the major feeding types in coarse sediments. Although a mechanical analysis of the bottom types was not made, it was evident (Table 3) that the finer sediments, clays and silts, predominated in the majority of the locations sampled. Deposit-feeding organisms, likewise, were the dominant species in each of the 12 sampling areas. The five most abundant species were: the stout razor clam, *Tagelus plebeius*; the bloodworm, *Glycera dibranchiata*; the common synapta, *Leptosynapta inhaerens*; the ornate worm, *Amphitrite ornata*; and the mud snail, *Nassarius obsoletus*.

The faunal populations, with respect to species and numbers, remained relatively constant from the first to the second sampling periods separated by an approximate two-year interval. Nine species were present in the winter survey of 1957 which were not found in the summer survey of 1959 when only 2 new species were added. The total numbers of organisms and species were somewhat greater in the first or winter survey, perhaps because the current year class of the spring and summer-spawning animals had attained sufficient size to be caught by the sampling gear.

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Young Black Drum, *Pogonias cromis*, in Tidal Fresh and Brackish Waters, Especially in the Chesapeake and Delaware Bay Areas[1]

Young black drum, ranging from 15–267 mm, were found in virtually fresh tidal waters (4 out of 86 records), but most often under brackish conditions in the Chesapeake and Delaware Bay areas. The sporadic records indicate that young are relatively uncommon. No relationship was found between size and salinity. Records suggest that *Pogonias cromis* spawns in offshore waters of the mid-Atlantic Ocean from March to May, and that the Chesapeake and Delaware Bay areas are at the northern limits of the effective spawning range. The larvae probably drift into the estuarine nursery areas thereafter by way of tidal currents, but these may be only a small part of a crop spawned offshore. The young apparently move offshore and perhaps southward again during the late fall. A marked low ratio of records of the young to adults was apparent. Young may be subjected to high mortality from unknown environmental factors; changing low temperatures in spring may be an important one.

The presence of young black drum, *Pogonias cromis* (Linnaeus), in virtually tidal fresh and slightly brackish water in the Chesapeake Bay region is an unusual phenomenon. Moreover, the young from the bay in available collections are scarce when compared to the common occurrence of adults, a young-adult relationship that is unusual for sciaenids in the middle Atlantic region. A review of the literature indicated that the occurrence of young is poorly documented for most of the Atlantic coast. Some recent original records combined with other unpublished and published observations provided the impetus for this critical review of the estuarine distribution and relative abundance of young *P. cromis* along the eastern seaboard, with special emphasis to tidal freshwater penetration of the species in Chesapeake and Delaware Bays (Tables 1 and 2).

Two young specimens of *Pogonias cromis* taken under very low salinity conditions in extreme upper Chesapeake Bay resulted in this attempt to bring our knowledge of the distribution of young up to date. They were seined at Oldfield Point, Elk River, Cecil County, in a 50 ft. bag seine (Table 1, Source A). In this paper, "young" are regarded as those fully-transformed sizes from 15 to roughly 275 mm. Pearson (1928:160) stated that the young have assumed the superficial adult characteristics at a size of 15 mm. For example, the 35 mm specimen (Table 1, Source Q) possessed barbels, was banded, and had a typical *P. cromis* shape, as shown in Fig. 1 herein and in Fig. 17 of Pearson (1929:159).

Although young *Pogonias cromis* are scarce in the mid-Atlantic coastal waters, the adults are relatively abundant. Hildebrand and Schroeder (1928: 289) stated that this species ranges from Massachusetts to Argentina, probably based on the distribution of the adult fish. In recent years, sizable schools of large adults have been reported in the Chesapeake Bay area and their runs are quite predictable. Truitt (1952:4) stated that the "Fisherman's Luck Trophy" has been won by sportsfishermen catching more *P. cromis* than any other species. Dr. F. J. Schwartz (1961:pers. comm.) recorded eight individuals from 32 to 39 inches long and weighing from 64 to 72 pounds which were killed by explosives off Barren Island, Cheseapeake Bay in June, 1958. Burton (1960:30) commented on large *P. cromis* which move into the Chesapeake Bay region in early May. He mentions a world's record from Maryland's Choptank River of just under 100 pounds.

Except for the information in Hildebrand and Schroeder (1928:287–9), a search of the literature revealed very little information on young *Pogonias*

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TABLE 1.—Records of young black drum, *Pogonias cromis*, found in virtually tidal fresh and brackish waters of Chesapeake and Delaware Bays and adjacent areas.

Source	No. of Specimens	Length[2]	Date	Salinity[3] (ppt)
I. Chesapeake Bay and adjacent waters—Maryland and Virginia				
A[1]	2	148, 190 mm	Oct. 5, 1960	0–2
B	1	178 mm	Sept. 24, 1959	1–6
C	1	165 mm	Aug. 14, 1958	9–10
D	1	140 mm	Aug. 21, 1958	8.5
E	1	160 mm	Aug. 27, 1958	10.9
F	1	"juvenile"	Aug. 13, 1957	11.8
G	1	267 mm	Sept. 24, 1957	15–18
H	1	194 mm	Sept. 26, 1956	11–14
I	1	ca. 127 mm	Sept. 1st week, 1954	5–9
J	1	146 mm	Aug. 24, 1948	12
K	1	126 mm	Aug. 23, 1936	8–12
L	1	162 mm	Aug. 23, 1934	12–15
M	20	171–252 mm	Sept. 27–Oct. 27, 1922	18–21
N	1	ca. 229 mm	Oct. 24, 1921	15–18
O	3	ca. 203 mm	Oct. 18, 1921	15–20
P	1	75 mm	Aug. 10, 1921	8–12
Q	1	35 mm	July 5, 1912	6–12[4]
R	1	160 mm	—	—
II. Delaware River, Bay, and adjacent region				
S	2	145, 155 mm	Aug. 22, 1960	2.2
T	—	—	Aug. 18, 1960	11.6
U	2	—	Nov. 13, 1959	0.1
V	1	127 mm	Aug. 26, 1959	4.7
W	3	120–135 mm	Aug. 26, 1959	7.2
X	1	57 mm	July 16, 1959	9.1
Y	—	72–214 mm	July–Oct. 1957	25
Z	4	93–105 mm	Sept. 12, 1957	5.8
AA	2	133–195 mm	Oct. 21, 1953	23.5
BB	1	110 mm	Oct. 6, 1953	23.0
CC	2	80, 112 mm	Sept. 1, 1953	22.9
DD	3	53–88 mm	Aug. 18, 1953	20.5
EE	4	40–73 mm	Aug. 3, 1953	19.8
FF	21	15–69 mm	July 9, 1953	20.4

[1] A. Md., Elk River, Oldfield Point, Cecil County, 3 ft. water, 50 ft. bag seine, C. M. Frisbie, L. W. Shearer, and D. Ritchie.

B. Md., Romney Creek, Harford County, hook and line, H. Jobes.

C. Md., Drum Point, Patuxent River, Calvert County, 100 ft. seine, R. J. Mansueti.

D. Md., Love Point, Chester River, Queen Anne's County, 100 ft. seine, E. H. Hollis.

F. Md., Shelltown, Pocomoke River, Somerset County, 100 ft. seine, E. H. Hollis.

G. Md., Off Governors Run, Chesapeake Bay, Calvert County, hook and line, Floyd Owen.

H. Md., Chesapeake Biological Laboratory Pier, Patuxent River, Solomons, Calvert County, hook and line, Arthur D. Jones.

I. Md., Mouth of Chew Creek, Patuxent River, Calvert County, hook and line, Philip Watson.

J. Md., Patuxent River, Solomons, Calvert County, 3 ft. water, 30 ft. bag seine, R. J. Mansueti.

K. Md., Unnamed Creek near Solomons, Calvert County, small seine, V. D. Vladykov.

L. Va., Off Urbana, Rappahannock River, USNM 93789, H. F. Kennedy, Jr.

M. Va., Ocean View, 1800 ft. haul seine, Hildebrand and Schroeder (1928:288,289).

N. Md., Lower Potomac River, St. Mary's County, Hildebrand and Schroeder (1928:288).

O. Va., Lower Rappahannock River, Hildebrand and Schroeder (1928:288).

P. Md., Mouth of Mill Creek, Solomons, Calvert County, small seine, Hildebrand and Schroeder (1928:288).

Q. Md., Parker Creek, Calvert County, USNM 74213, Weed, Palmer, Wallace.

R. Va., Norfolk, USNM 3437, Jefferies.

S. N. J., Salem Cove, Delaware Bay, near Salem, Salem County, 60 ft. seine and 5% Pro-noxfish, D. P. de Sylva and F. Kalber.

T. Del., Indian River, Sussex County, F. T. Carlson.

U. Del., Off Deepwater, N. J., Delaware River, P. E. Hamer.

V. N. J. Salem Beach, Delaware Bay, 60 ft. seine, D. P. de Sylva, W. P. Davis.

W. Del. Augustine Beach, Delaware Bay, Kent County, 60 ft. seine, D. P. de Sylva, W. P. Davis.

X. N. J. Marsh drainage ditch, near Fortesque, off Delaware Bay, Cumberland County, Pro-noxfish and dipnet, D. P. de Sylva and W. P. Davis.

Y. Del., White Creek, Indian River, Sussex County, F. T. Carlson.

Z. Del., Off Deepwater, N. J., Delaware River, P. E. Hamer.

AA. Del., Kitts Hummock, Delaware Bay, hand seine, F. C. Daiber.

BB. Del., Kitts Hummock, Delaware Bay, hand seine, F. C. Daiber.

CC. Del., Kitts Hummock, Delaware Bay, hand seine, F. C. Daiber

DD. Del., Kitts Hummock, Delaware Bay, hand seine, F. C. Daiber

EE. Del., Kitts Hummock, Delaware Bay, hand seine, F. C. Daiber.

FF. Del., Kitts Hummock, Delaware Bay, hand seine, F. C. Daiber.

[2] Measurements of specimens from Sources A through X are total lengths while those from 12 through FF are standard lengths.

[3] Salinities were estimated where a range is given, based on Beaven (1960) and Whaley and Hopkins (1952).

[4] Estimated salinity of Chesapeake Bay at mouth of Parker Creek. The possibility exists that specimen could have been taken from fresh water, depending on how far up the creek it was taken.

cromis in the Chesapeake Bay area, and nothing of its occurrence in tidal fresh or slightly brackish water. Table 1, which will be discussed later, will augment these records, and shows the paucity of specimens from low saline waters. Table 2, which makes essentially the same point, gives unpublished and published records of young *P. cromis* along the Atlantic coast covering a wide span of years. The number of specimens presented here are small and the data is incomplete in that numbers, salinities and, in some cases, dates of capture are missing. Probably additional unpublished information is available to lengthen this list, but the latter is probably representative of the occurrence of the species in low salinities. It is pertinent to state that a wide

TABLE 2.—Records of young *Pogonias cromis* from other points on the Atlantic Coast based on unpublished and literature sources.

Number of Specimens	Size Range	Salinity	Date	Locality	Authority
Unknown	ca. 6 inches	Unknown	September Year Unknown	New York, Sea Coast	Dekay (1843:82)
Unknown	Young	>25	August Year Unknown	New Jersey, Beesley's Point	Baird (1854:332)
14	ca. 8 inches	>	Fall, 1896	New York, Gravesend Bay	Bean (1903:434)
1	Small	>25	May, 1912	Virginia, Chincoteague	Fowler (1913:65)
1	170 mm	ca. 31.5 ppt	1930	Georgia, Brunswick	USNM 127504 (Anderson, W. W.)
1	217 mm	Unknown	Unknown	Florida, Matanzas River Inlet	USNM 18036 (Willetts)
1	73 mm	21–33 ppt	June 30, 1932	South Carolina, Seabrook's Beach	Fowler (1945:113)
1	305 mm	Unknown	May 30, 1933	South Carolina, Cape Inlet	Fowler (1945:113)
7	17–43 mm	20.6–26.1 ppt	May, 1955	Florida, Cedar Key	Kilby (1955:226)
2	49–83 mm	20.6–26.1 ppt	June, 1955	Florida, Cedar Key	Kilby (1955:226)
1	121 mm	ca. 33.7	July, 1952	Florida, Alligator Harbor	Joseph & Yerger (1956:139)
2	143–247mm	20.5–23.1 ppt	Nov. 14, 1957	Florida, Cross Bayou	Springer and Woodburn (1960:63)
2	220–250 mm	Unknown	Unknown	South Carolina, Charleston	USNM 24690 (Earl, R. E.)

variety of shallow and deepwater fishing gear have been employed at all seasons throughout the bay, as indicated for *Sciaenops ocellata* (Mansueti, 1960: 207). It is concluded that the paucity of records is a real rather than an apparent condition.

Most of the literature on young *Pogonias cromis* and their salinity tolerance deals with the Gulf States. Pearson (1929) gave extensive data on spawning, characteristics of larvae and young, and distribution of young *P. cromis*, but he did not list them as occurring in tidal fresh water. Gunter (1942:345) was the first to include *P. cromis* in a list of fishes found in both tidal fresh and sea water. Gunter (1945:74–126; 1956:350) dealt extensively with the euryhalinity and distribution of *P. cromis* into low salinity areas. In the first reference, he recorded 174 specimens from Texas coastal waters. Of these 124 were caught in Copano Bay, which had, for that year, an average salinity of 9.1 ppt. On the Gulf beach, 15 were taken where the salinity averaged 31.5 ppt. Both young and adult *P. cromis* were included in these catches. Three small specimens measuring 81–85 mm were seined on June 22, 1942 in Aransas Bay where the salinity for that month ranged from 18.2 to 34.0 ppt. Gunter's data pointed out that the majority of *P. cromis* were taken from salinities of 10.0 to 15.0 and those remaining were fairly evenly distributed at other salinities. The lowest salinity from which Gunter (1945:74) took *P. cromis* was 2.6 ppt. Apparently only a few specimens were found in this low salinity as there were only 14 listed from salinities up to 4.9 ppt. This data suggests that the occurrence of *P. cromis* in low saline waters in Texas is an uncommon occurrence.

Part I of Table 1 gives data on the distribution of young *Pogonias cromis* in the Chesapeake Bay and adjacent waters, based largely on unpublished Maryland records. It is of interest to note that all specimens recorded here, with the exception of the one from Source Q, were taken during August, September and October. Recently a few specimens from 200–275 mm total length have been reported from pound net catches in April at the mouth of the Honga River where the salinity was 10–12 ppt. There is no evident correlation between size of fish and salinity. This conclusion is shown in Fig. 1, which summarizes size groups in relation to approximate average salinity conditions known for Chesapeake and Delaware Bays and their estuaries.

The Elk River specimens (Source A), seined in an area where water is usually fresh but may reach 2 ppt, are apparently from the lowest salinity in the Chesapeake area. The fishes associated with *P. cromis* in the seine collection were represented by a few euryhaline freshwater forms and the rest were euryhaline estuarine species. They included: brown bullhead, *Ictalurus nebulosus*; eastern spottail shiner, *Notropis hudsonius amarus*; sunfish, *Lepomis* sp.; white perch, *Roccus americanus*; striped bass, *R. saxatilis*; bay anchovy, *Anchoa mitchilli*; tidewater silverside, *Menidia beryllina*; fourspine stickleback, *Apeltes quadracus*; sheepshead minnow, *Cyprinodon variegatus*; mummichog, *Fundu-*

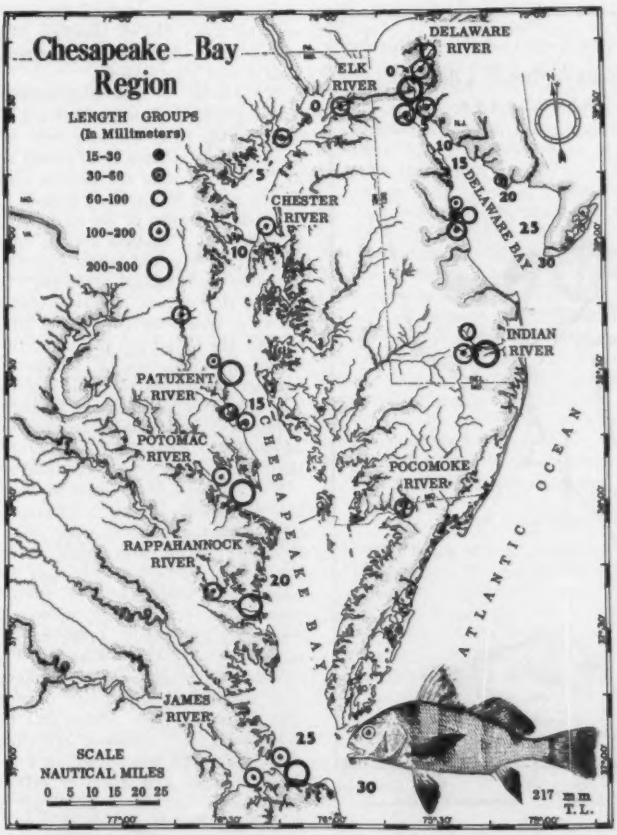

Fig. 1.—Distribution of young black drum, *Pogonias cromis*, by length groups in the Chesapeake and Delaware Bay regions. The surface salinity figures (0, 5, 10 etc.) are gross approximations by area. The illustration of the 217 mm young is a drawing by H. L. Todd from Goode (1884:atlas, pl. 121), based on a specimen from the Matanzas River inlet, Florida (Table 2).

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Nearby Delaware Bay waters have yielded some important and as yet unpublished records of young *Pogonias cromis*. Part II of Table 1 gives data on the distribution of young in the Delaware Bay area. As with the Chesapeake records the young were taken from July to October. However, 2 young specimens (Source U), taken in November, were from the lowest salinity, 0.1 ppt. The largest collection was made in July as compared with September for the Chesapeake Bay specimens. The salinity pattern for Delaware records is generally higher than for the Chesapeake, with a range of 0.1 to 25+ ppt. The specimens in Part II, listed as Source AA to FF, were all taken from Kitts Hum-

TABLE 2.—Records of young *Pogonias cromis* from other points on the Atlantic Coast based on unpublished and literature sources.

Number of Specimens	Size Range	Salinity	Date	Locality	Authority
Unknown	ca. 6 inches	Unknown	September Year Unknown	New York, Sea Coast	Dekay (1843:82)
Unknown	Young	>25	August Year Unknown	New Jersey, Beesley's Point	Baird (1854:332)
14	ca. 8 inches	>	Fall, 1896	New York, Gravesend Bay	Bean (1903:434)
1	Small	>25	May, 1912	Virginia, Chincoteague	Fowler (1913:65)
1	170 mm	ca. 31.5 ppt	1930	Georgia, Brunswick	USNM 127504 (Anderson, W. W.)
1	217 mm	Unknown	Unknown	Florida, Matanzas River Inlet	USNM 18036 (Willetts)
1	73 mm	21–33 ppt	June 30, 1932	South Carolina, Seabrook's Beach	Fowler (1945:113)
1	305 mm	Unknown	May 30, 1933	South Carolina, Cape Inlet	Fowler (1945:113)
7	17–43 mm	20.6–26.1 ppt	May, 1955	Florida, Cedar Key	Kilby (1955:226)
2	49–83 mm	20.6–26.1 ppt	June, 1955	Florida, Cedar Key	Kilby (1955:226)
1	121 mm	ca. 33.7	July, 1952	Florida, Alligator Harbor	Joseph & Yerger (1956:139)
2	143–247mm	20.5–23.1 ppt	Nov. 14, 1957	Florida, Cross Bayou	Springer and Woodburn (1960:63)
2	220–250 mm	Unknown	Unknown	South Carolina, Charleston	USNM 24690 (Earl, R. E.)

variety of shallow and deepwater fishing gear have been employed at all seasons throughout the bay, as indicated for *Sciaenops ocellata* (Mansueti, 1960: 207). It is concluded that the paucity of records is a real rather than an apparent condition.

Most of the literature on young *Pogonias cromis* and their salinity tolerance deals with the Gulf States. Pearson (1929) gave extensive data on spawning, characteristics of larvae and young, and distribution of young *P. cromis*, but he did not list them as occurring in tidal fresh water. Gunter (1942:345) was the first to include *P. cromis* in a list of fishes found in both tidal fresh and sea water. Gunter (1945:74–126; 1956:350) dealt extensively with the euryhalinity and distribution of *P. cromis* into low salinity areas. In the first reference, he recorded 174 specimens from Texas coastal waters. Of these 124 were caught in Copano Bay, which had, for that year, an average salinity of 9.1 ppt. On the Gulf beach, 15 were taken where the salinity averaged 31.5 ppt. Both young and adult *P. cromis* were included in these catches. Three small specimens measuring 81–85 mm were seined on June 22, 1942 in Aransas Bay where the salinity for that month ranged from 18.2 to 34.0 ppt. Gunter's data pointed out that the majority of *P. cromis* were taken from salinities of 10.0 to 15.0 and those remaining were fairly evenly distributed at other salinities. The lowest salinity from which Gunter (1945:74) took *P. cromis* was 2.6 ppt. Apparently only a few specimens were found in this low salinity as there were only 14 listed from salinities up to 4.9 ppt. This data suggests that the occurrence of *P. cromis* in low saline waters in Texas is an uncommon occurrence.

Part I of Table 1 gives data on the distribution of young *Pogonias cromis* in the Chesapeake Bay and adjacent waters, based largely on unpublished Maryland records. It is of interest to note that all specimens recorded here, with the exception of the one from Source Q, were taken during August, September and October. Recently a few specimens from 200–275 mm total length have been reported from pound net catches in April at the mouth of the Honga River where the salinity was 10–12 ppt. There is no evident correlation between size of fish and salinity. This conclusion is shown in Fig. 1, which summarizes size groups in relation to approximate average salinity conditions known for Chesapeake and Delaware Bays and their estuaries.

The Elk River specimens (Source A), seined in an area where water is usually fresh but may reach 2 ppt, are apparently from the lowest salinity in the Chesapeake area. The fishes associated with *P. cromis* in the seine collection were represented by a few euryhaline freshwater forms and the rest were euryhaline estuarine species. They included: brown bullhead, *Ictalurus nebulosus*; eastern spottail shiner, *Notropis hudsonius amarus*; sunfish, *Lepomis* sp.; white perch, *Roccus americanus*; striped bass, *R. saxatilis*; bay anchovy, *Anchoa mitchilli*; tidewater silverside, *Menidia beryllina*; fourspine stickleback, *Apeltes quadracus*; sheepshead minnow, *Cyprinodon variegatus*; mummichog, *Fundu-*

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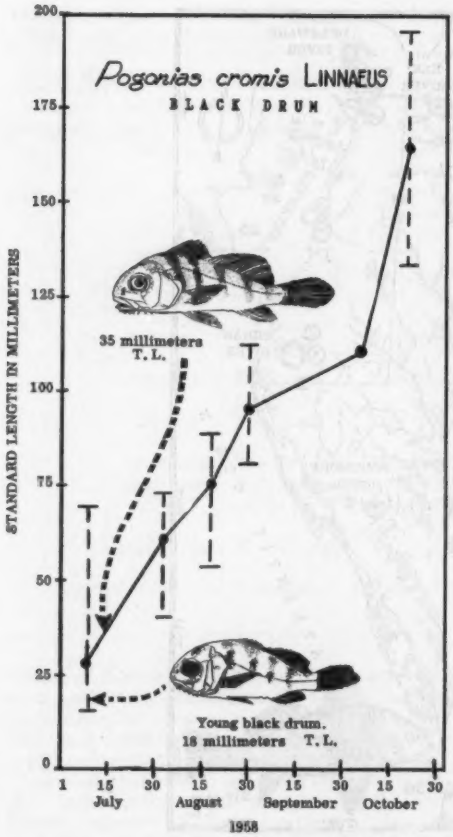

Fig. 2.—Growth curve of young black drum, *Pogonias cromis*, as reflected by the average size of samples taken on various dates from Kitts Hummock, Delaware Bay, based on unpublished data provided by Dr. Franklin C. Daiber, University of Delaware Marine Laboratory. Black dots are mean values and dotted lines show range of sizes taken on a particular date. The illustrations are from Pearson (1929:158). See Table 1.

mock during the course of an 11-month shore sampling from five stations along Delaware Bay by Dr. Franklin C. Daiber of the University of Delaware Marine Laboratory. These were listed in Shuster (1960, XXI:20–1). The growth curve from these 33 young specimens is given in Fig. 2, showing a strong and reasonably steady growth increment. Fig. 2 also suggests that the rate of growth can provide an insight into the approximate spawning period in Delaware waters. From the growth rates of two closely related young sciaenids (Hildebrand and Cable 1934:64, 108), it is possible to extrapolate the approximate spawning period of the specimens caught in July. This period would probably be from March through May, which agrees well with the estimate of Pearson (1928:164) for Gulf Coast populations.

Knowledge of the distribution of young *Pogonias cromis* in North and South Carolina, Georgia and Florida from the literature is sketchy at best. Such records as have been found are given in Table 2. They emphasize the general lack of information on the young in all these waters.

Little is known of the early life history and distribution of *Pogonias cromis* along the Atlantic coast. The eggs and larvae (up to 4.5 mm) are apparently undescribed. Pearson (1928:158) gave a limited description of larvae and young exceeding 4.5 mm, based on collections from Texas coastal waters. He found (p. 164) that the main spawning season in Texas coastal waters in the vicinity of Corpus Christi Bay is from late February to May. The spawning grounds are probably located at the mouths of the passes leading into the Gulf of Mexico. He believed that larval *P. cromis* make their way into the bays via tidal currents.

The fact that no evidence has been found of larval *Pogonias cromis* in Chesapeake Bay suggests that spawning does not take place in these waters. Pearson (1941), who made an extensive almost year-round survey of fish eggs and young at the mouth of Chesapeake Bay, found no evidence of planktonic forms of *P. cromis*. Hildebrand and Schroeder (1928:288), however, listed a ripe adult male taken at Cape Charles, Virginia, near the mouth of Chesapeake Bay, which might indicate that spawning takes place offshore and adjacent to Chesapeake Bay. Uhler and Lugger (1876:99), in referring to *P. cromis* in Maryland coastal waters, stated that "In the spawning season it enters the different bays and inlets of salt water to deposit its spawn," but they gave no data to support this claim. The fragmentary data suggests that the larger fish, after spawning probably from March through May, then move into the Chesapeake and Delaware Bays in May, followed by the young in July and August, to forage in the estuarine nurseries until November or December, at which time they probably migrate seaward and southward to warmer waters. Some may overwinter near the bay, as evidenced by the commercial capture of 8–10 inch individuals, apparently yearlings, in April from the Maryland part of the bay.

The distribution of young *Pogonias cromis* on the Atlantic coast seems to follow that of the species in Texas coastal waters as given by Pearson (1928:160); that is, the young tend to seek out shallow bay and shore areas where they probably remain until they exceed 300 mm, afterwards probably scattering over the extent of their range. Records indicate that young *P. cromis* enter the Chesapeake Bay and Delaware Bay areas shortly after the adults. They disperse over an appreciable salinity range, with a small minority venturing into low salinity or even tidal fresh water. The pattern of distribution of adults in the Chesapeake and Delaware Bay areas, as far as is known at present,

seems to be similar to that of the Gulf Coast populations, although they differ in time and space.

The explanation for the paucity of records of young *Pogonias cromis* is difficult at this time, although the environmental factors at the northern limit of its spawning range may exercise an important influence on survival of young. The Chesapeake and Delaware areas are probably at the upper limit of the spawning range and also represent the northernmost waters containing relatively large populations of adults. This species apparently has a low tolerance to sudden temperature changes during cold periods. Pearson (1928:173), Gunter (1941:208), and Gunter and Hildebrand (1951:732, 753) cited examples of mortality of *P. cromis* caused by cold waves on the Texas coast. Gunter (1941: 205) considered 1- to 4-pound *P. cromis* as among the most abundant species killed by the cold wave at Copano Bay, Texas. Bean (1903:434) stated that a low water temperature of 38° F killed young *P. cromis* which were being held in an aquarium. Eggs and larvae in the mid-Atlantic region probably would only be subjected to critical low temperature changes from March through May, as suggested by the wide ranges of temperatures that were encountered over the continental shelf off Chesapeake Bay (Joseph, et al, 1960:162). Since spawning of *P. cromis* is in spring rather than in winter, this factor may not be limiting as has been postulated for the croaker during abnormally cold periods when the larvae are present in Chesapeake Bay (Massmann and Pacheco, 1960:158). In fall young *P. cromis* would be subjected to similar changes of temperature with the onset of winter, but this is after the major factors have been operative in spring and early summer to bring on the apparent scarcity. As far as is known now, declining temperatures act as a catalyst inducing black drum to seek warmer waters in late fall.

It is possible that those larvae and young entering the mid-Atlantic estuaries represent but an incidental number of newly hatched *Pogonias cromis* from offshore waters. The balance of individuals spawned may move offshore or southward to some other nursery, or otherwise become unavailable to ordinary sampling methods. These may take part in migrations to the Chesapeake and Delaware Bays as adults at a later time. This pattern of life history, however, is unlike that of most sciaenids, hence its importance as an explanation is difficult to judge with so few facts. Available records by a variety of collecting methods in more southern waters have generally indicated that the young are also relatively scarce, thus the problem is compounded.

Young *Pogonias cromis* may enter tidal fresh and low saline waters of the Chesapeake and Delaware Bay areas as larvae, which presumably follow the pattern of influx into these systems as proposed for *Sciaenops ocellata* by Mansueti (1960:207). Thus, the planktonic young may enter the low saline waters by way of the sub-surface tongues of high saline waters having a net upstream flow (Pritchard 1951:375). As they become free-swimming they may then leave the deeper, more saline waters to forage temporarily in the shallow and fresher estuaries. Since only a few very small specimens have been taken under these conditions, it may be suggested that young *P. cromis* is only a temporary visitor to these areas.

Acknowledgments:—Appreciation is gratefully extended for the contribution of data from: Dr. Franklin C. Daiber, University of Delaware Marine Laboratory; Dr. Donald P. de Sylva, formerly of the University of Delaware Marine Laboratory; Dr. Leonard P. Schultz, Division of Fishes, U. S. National Museum; Mr. Paul E. Hamer, New Jersey Marine Fisheries Laboratory; Mr. Frank Carlson, U. S. Bureau of Commercial Fisheries Laboratory, Millville, Delaware; Mr. E. H. Hollis, Maryland Department of Tidewater Fisheries, and Mr. B. H. Cheeseman of the Deepwater Power Station, Penns Grove, New Jersey. Special thanks are given to Dr. Romeo J. Mansueti of the Chesapeake Biological Laboratory for his helpful suggestions, use of personal library, and for critically reviewing the manuscript; and to Dr. Frank J. Schwartz who also provided library assistance, data, and suggestions.

Conclusions

1. Young black drum, *Pogonias cromis*, totalling 86 specimens, ranged from 35–267 mm in Chesapeake Bay, and 15–195 mm in Delaware Bay, were distributed as follows: <2 ppt salinity—4%; 2–10 ppt—15%; 10–20 ppt—43%; and 20–30 ppt—35%.
2. No relationship between size and salinity was discerned among the young. Its occurrence in fresh water is incidental to its widespread predilection for brackish waters. Most records occur from August through October, with some in July and November. Young, apparently yearlings, have been recorded in the commercial catches in April.
3. Distributional patterns of young *P. cromis* in the Chesapeake-Delaware Bay areas are similar to those of Texas coastal waters; i.e., after hatching from March to May in offshore waters, some larvae probably drift inshore by way of tidal currents, and they utilize shallow bays as nursery areas. They may move offshore again during late fall. Chesapeake and Delaware Bays are considered the northern limit of the effective spawning range.
4. Sporadic records indicate that young in the Chesapeake area are relatively uncommon. Perhaps the mid-Atlantic estuaries are used as nursery areas incidental to other more desirable regions. On the basis of an apparent low ratio of young to adults, it is theorized that environmental factors, particularly changing low temperatures in spring, may limit movements or survival of young.

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A record of the Mississippi map turtle, *Graptemys kohni*, in Maryland[1]

ABSTRACT

The record of the Mississippi map turtle, *Graptemys kohni*, in Maryland's Patuxent River brings the total of introduced forms to six. It was found in water with a salinity of 5.3 ppt. Notable was the large barnacle, *Balanus*, attached to the rear of the carapace. Body measurements and comments regarding its salinity tolerance are presented.

On April 27, 1960 a Mississippi map turtle, *Graptemys kohni* Baur, (USNM 142398) was captured by a commercial haul seiner in the Patuxent River at Jones Point some 2¼ miles southwest of Lower Marlboro, Calvert County, Maryland. The identity of this specimen was confirmed by com-

[1] Contribution No. 181, Maryland Department of Research and Education, Solomons, Maryland.

paring it with typical *kohni* from Rayville, Louisiana (USNM 100472) and Washington, Mississippi (USNM 7726).

Carapical and plastral lengths and widths were 238 x 175 and 205 x 113 mm, respectively. Other measurements (in mm) taken of this specimen included: head to occiput 73.0, maximum width of head 40.1, maximum width of upper jaws 33.1, distance snout to a straight line running between the corners of the jaws 21.7, symphysis 15.3, interorbital 10.2, and orbit length and height 12.8 x 11.4.

The discovery of *G. kohni* brings the total of introduced turtles, in Maryland, to six: *Pseudemys scripta troosti*, Cumberland turtle (Mansueti 1941:43; McCauley 1945:25); *Pseudemys s. elegans*, red-eared turtle (Cooper 1959:44); *Trionyx ferox spinifera*, Eastern spiny softshell turtle (Mansueti and Wallace 1960:71–2); *Graptemys pseudogeographica*, false map turtle; *Geoclemmys reevesi* (Cooper 1961); and *G. kohni*, Mississippi map turtle. The genus *Graptemys* is thus represented by three species: one occurring normally, *G. geographica*, and two introduced, *G. kohni* and *G. pseudogeographica*. *G. geographica* is known from Havre de Grace and the Conowingo Dam area of the Susquehanna River in Cecil and Harford Counties (USNM 17833, 141523-8). *G. pseudogeographica* is known only from a specimen (USNM 139658) collected by J. A. Fowler on May 18, 1940 near Analostan Island, of Potomac River.

The normal range of *G. kohni* includes eastern Texas, Oklahoma, Kansas, Nebraska, east to the Mississippi River and southern Indiana (Cagle 1957:291; Conant 1958:52). This species could have been established in Maryland by someone obtaining a specimen from its original range and later discarding it near or in the Patuxent River, or the specimen was a pet (most graptemids are sold as children's pets in dime stores) which became too large for the household and was discarded or escaped. Cooper (1961) reported a juvenile *G. kohni*, undoubtedly a dime store specimen, captured on May 25, 1960 in Wagner's Pond near Glen Burnie, Anne Arundel County.

The present specimen seems to have been acclimated to the Patuxent River as it was found in water with a salinity of 5.3 ppt. Another indication of its having spent some time in brackish water was the fairly large barnacle, *Balanus* sp., which was attached to the rear of the carapace. Neill's (1958:19–35) review of the literature on reptiles in saltwater areas makes no mention of a graptemid having been found in brackish waters. Cagle (personal letter June 28, 1960) has taken all species of *Graptemys*, with the exception of *G. versa*, in brackish waters; however, both he and Dr. G. Gunter of Mississippi stress the lack of ecological data regarding the extent or duration of salinity tolerance for *G. kohni*.

Thanks are due Mr. Orem Lowry and his crew of haul seiners: W. Denton, A. C. Elliott, Jr., B. Elliott and W. Barnes, all of Broomes Island, Maryland, for bringing this specimen to our attention; Dr. Doris Cochran, Curator, Division Reptiles and Amphibians, U. S. National Museum for assistance when comparing the above specimen with typical *kohni* and access to the division files for Maryland graptemid records; Drs. F. Cagle, Coordinator of Research, Tulane University, and G. Gunter, Director, Gulf Coast Research Laboratory, Ocean Springs, Mississippi, for comments regarding the ecological requirements of this species in its normal range.

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A Sixteen Pound Pugheaded Striped Bass from Massachusetts

ABSTRACT

A new record of a pugheaded striped bass, *Roccus saxatilis*, weighing 16¼ pounds, is described and illustrated. It was taken by an angler off Nantucket, and resisted capture as a normal fish. It seemed in good condition except for the deformity, and its stomach contained sea herring.

I read with interest the account of the pugheaded striped bass, *Roccus saxatilis* (Walbaum), by Mansueti (1960:111–3). A record of a specimen of considerably greater size, weighing 16¼ pounds, showed

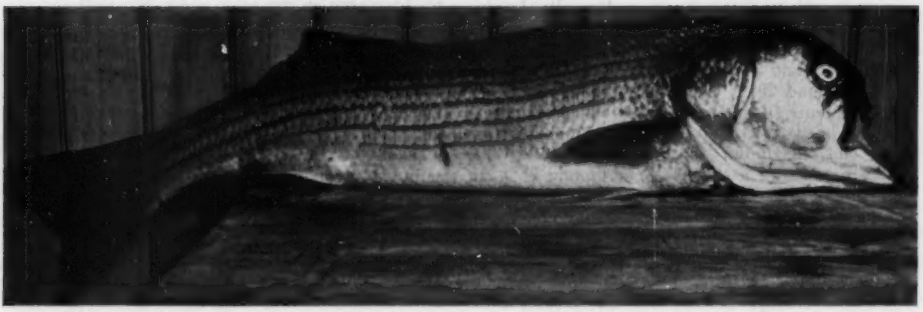

Fig. 1.—A pugheaded striped bass, *Roccus saxatilis*, weighing 16¼ pounds, caught off Nantucket, Massachusetts, by Irving E. Sandsbury, October 23, 1948.

this same odd deformity (Fig. 1). This photograph was first used in Woolner and Lyman (1954:14), but the date of catch is erroneously reported therein as 1949. The fish was taken on an Atom plug off Great Point, Nantucket, Massachusetts, by the late Irving E. Sandsbury on October 23, 1948. The photograph used in Fig. 1 has been retouched slightly to make a sharper engraving for publication, but the art work is of a minor nature.

I did not see this specimen, but talked to Sandsbury about it shortly after the catch was made. I also talked to at least a half dozen people who saw the fish and witnessed the weighing of it. Sandsbury stated that the fish was in good shape except for its deformity, struck the plug while he was casting from the beach in the tide rips at Great Point, and fought much like an ordinary fish, although he said it "gave up a little quicker." It had been feeding on sea herring, *Clupea harengus*. I presume because of its size and because of the locality in which it was caught, this specimen might have been a female, although I have no proof of this. Unfortunately the fish was in the stewpot by the time I received the photo or I would have grabbed it either for Woods Hole or Harvard.

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HENRY LYMAN

The Salt Water Sportsman,
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Waterfowl Predation by and Records of the Great Black-Backed Gull in Chesapeake Bay During Winter and Spring[1]

ABSTRACT

Great black-backed gulls, *Larus marinus*, were observed to attack and kill lesser scaup, ruddy duck, and the horned grebe in the Chesapeake Bay region during late winter and early spring. Waterfowl predation by this gull has been reported in more northern waters. Such behavior is of little importance in the total mortality of ducks. Records indicate that, while sporadic in occurrence, this gull is apparently more common in Chesapeake Bay during very cold winters than has previously been reported, and is increasing in numbers in this region.

[1] Contribution No. 182, Maryland Department of Research and Education, Solomons, Maryland.

This note describes predation upon ducks and grebes in southern waters and cites new distributional records of the great black-backed gull, *Larus marinus* (Linnaeus), in Chesapeake Bay during winter and early spring months. On March 14, 1955, while working with a commercial haul seiner in the upper Chesapeake Bay in the Northeast River at Northeast, Cecil County, my wife and I observed three great black-backed gulls flying among several dozen herring gulls, *Larus argentatus*, near a large raft of scaups and other ducks. As the three gulls hovered over the duck flock, one of the former dove down into them, striking one of the ducks on the head region with its beak. As the surrounding ducks flew off, the two other black-backed gulls made similar passes at the duck, injuring it so that it could not fly. The first gull made another pass, lifting the duck partly out of the water, and drop-

ping it. One of the gulls alighted, followed by the third, and proceeded to pick viciously at the foundering duck. The first gull also alighted, shrieking loudly, and fought off its companions. It also picked vigorously at the now lifeless duck. A fisherman in a skiff nearby rowed over, frightened off the gull, and dipped the duck out of the water. When it was brought to shore, it was identified as a lesser scaup, *Aythya affinis*, with the aid of Peterson (1947:34). Its plumage was greatly ruffled, and the head region was bloody. Within the next half hour, the three black-backed gulls were observed to attack several other ducks, single out an individual, and concentrate their attacks on it. One was apparently injured, but its fate could not be determined.

On March 21, 1955, a single black-backed gull was observed to dive into another flock of ducks in the Northeast River. After one was separated from the group, the gull swooped over it continuously, striking at it and shrieking loudly. As the duck's movements subsided, its attacker settled on the water, and struck at its prey with continued fervor. A fisherman interrupted the proceedings, and the almost lifeless ruddy duck, *Oxyura jamaicensis*, was brought aboard.

Local fishermen stated that visitations and waterfowl predation by the great black-backed gull was a common occurrence in Northeast River, as well as in the upper Chesapeake Bay. They distinguished with ease the black-backed gull from the abundant herring gulls. The attacks upon ducks were said to be most commonly observed during late February and March as the ducks concentrated in preparation for the spring migration. They believed that the gulls singled out sick and injured birds during most of such depredations. Attacks upon flocks of unidentified ducks were also observed from about ½ mile in the Potomac River on March 7, 1957.

During January and February, 1961, when the Patuxent River mouth was partly iced over for several weeks at a time, Mr. Hayes Pfitzenmeyer observed a great black-backed gull attack the horned grebe, *Podiceps auritus*. The gull swooped down on the actively diving grebe until apparently from exhaustion it became easy prey for the huge gull. While it sat on the water pecking vigorously at its victim, several herring gulls circled calling loudly.

The aggressive, predatory nature of the great black-backed gull is well-known, although no attempt has been made to describe details of this behavior in American waters. Tinbergen (1960:26) pointed out that there are many scattered references to the ornithophagous behavior of the great black-backed gull in European waters. This is not to say that such is not the case in American waters. The only reference to predation upon the scaup by this large gull is given obliquely by Hickey (1943: 94). Nuttall (1903:II:253) remarked, "As Mr. Audubon justly and strongly remarks, it is as much the tyrant of the sea-fowl as the eagle's is of the land-birds. * * * It is the particular enemy of the graceful Eider, pouncing upon and devouring its young on every occasion, and often kills considerable-sized ducks." Peters and Burleigh (1951: 226–7) repeated the latter fact on eider ducklings. Forbush (1925:I:71) stated, "It kills and devours Dovekie and other small birds, young ducklings and the eggs and young of other birds, young mammals . . ." He quoted some interesting observations regarding predation on the American coot, "A daily toll is taken by several Black-backed gulls; these gulls hover over the ducks, dip down and take one every few minutes, then leave to come back again when hungry . . . These Blue Peters seem to lose all idea of escape, just rush around on top of the water and it's only a matter of time or the number of Black-backs that will put the whole bed of fowl out of running." He also declared further that, "It eats dead ducks and sometimes crippled ducks that it has killed. It can carry a full-grown scoter." The latter type of scavenging is apparently common. Tinbergen (1960:26), for example, cited the fact that during unusually cold winters on the Dutch North Sea coast, they were observed to feed and prey upon dead and dying oyster-catchers, curlews, and ducks. He also described an unusual attack and killing of a sandwich tern, *Thalasseus sandvicensis*, by the great black-backed gull.

During trawling cruises in Chesapeake Bay during the late fall and winter of 1958 and 1959, I observed a number of great black-backed gulls in mid-bay. These have no particular significance since the species typically prefers offshore waters, but they illustrate the fact that many interesting species may be observed far offshore. These records include: 7–9 I '58: Kent County, off Worton Point, 9 on ice in mid-bay; Baltimore County, off Patapsco River mouth; St. Mary's County, off Point-no-Point, and mid-bay. 16–18 XI '59: Anne Arundel County, off Annapolis, 2 miles west of Matapeake, Calvert County, flying offshore of Cove Point; Talbot County, 2½ miles west of Sharps Island Light, one observed flying among gannets as they dove and settled on the water during a rough sea.

Stewart and Robbins (1958:157) regarded the great black-backed gull as: "Transient and wintering: Fairly common in the coastal area of Worcester County, uncommon in tidewater areas elsewhere in the Eastern Shore and Western Shore sections; rare in tidewater areas in the Upper Chesapeake section." Although they give records for every season, presumably based largely on shore observations, their citations are restricted to a relatively few locations. Mr. Chandler S. Robbins, Biologist, Section of Migratory Bird Studies, U. S. Fish and Wildlife Service, kindly provided me (*in litt.* June 8, 1961) with a synthesis of present knowledge concerning the status of the great black-backed gull in the Maryland region. He pointed out that published records in *Maryland Birdlife*, *Audubon Field Notes*, and *Atlantic Naturalist* show that there has been a marked increase in the sightings of the great black-backed gull in the Chesapeake Bay area during the past decade. *Maryland Birdlife* contains about 50 references to the species. Ornithologists

now regard it as a regularly occurring winter form throughout Chesapeake Bay and its estuaries. On the 1959–1960 Christmas Bird Count, 162 great black-backed gulls were counted in the Maryland portion of the bay and tidal rivers. Records exist for all months except July and for all Coastal Plain counties except Wicomico. Examples of high Christmas Counts in recent years are: Annapolis area (3 I '60)—21; southern Dorchester County (31 XII '58)—19; lower Kent County (31 XII '60)—37); St. Michaels area, Talbot County (27 XII '59)—72; Palmers, St. Marys County (Xmas '60)—32 (Banagan, 1961:113).

Mr. Robbins indicated that there has been a real increase in the great black-backed gull in Maryland during the past decade in response to its tremendous increase in the north and the southward extension of its breeding range. The increase in Maryland is well documented in the various published Christmas Bird Counts and in *Maryland Birdlife*, where the raw materials are available to demonstrate an important population problem among these gulls.

Conclusions:—The great black-backed gull, while sporadic in the past, is more common in Chesapeake Bay than has previously been reported. Records of its occurrence will increase, especially after more ornithologists visit all parts of tidewater and cruise the bay during colder periods. This is especially true during unusually cold winters. Its predation upon ducks and other waterfowl is a relatively unusual phenomenon, probably because of the small numbers of these large gulls in relation to the great numbers of waterfowl wintering in bay waters. Such behavior is of little importance in the total mortality of waterfowl, a conclusion that is backed up by fragmentary references on predation in more northern waters, where the ratio of gulls to ducks is much higher. Although there is evidence that this aggressive gull is increasing in the Chesapeake region, there is little possibility that waterfowl predation will also increase.

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Appearance of the Gag, *Mycteroperca microlepis*, in Coastal Waters of Virginia[1]

ABSTRACT

Eighteen young gag, *Mycteroperca microlepis*, 61–186 mm F.L., were recorded from Chincoteague Bay, Eastern Shore waters, off Virginia Beach, and within Chesapeake Bay from July to November 1960. Average lengths at progressive collecting periods suggest rapid growth. Coloration and pattern varied somewhat among the specimens.

The gag, *Mycteroperca microlepis* (Goode and Bean), a grouper common to Florida waters with a range extending northward beyond Virginia, has not been commonly reported in Virginia before 1960 except for isolated specimens. One fish was taken at Old Point Comfort (Evermann & Hildebrand, 1910) and three others reported from Virginia, no specific locations (Smith, 1959). During 1960 several small specimens were taken (Table 1), suggesting ingress of young-of-the-year fish.

Specimens were collected in Chincoteague Bay and near Wachapreague on the Virginia Seaside. Within Chesapeake Bay they were taken just north of Cape Charles City, at Kiptopeke, near Fort Wool, and off the mouth of Back River. Five unverified gags were reported taken by sport fishermen at the Virginia Beach steel pier and one specimen was trapped in an eel pot at Gloucester Point. All other records except the fish from the mouth of Back River are represented by specimens.

Lengths taken (Table 1) suggest rapid growth if

[1] Contribution from the Virginia Fisheries Laboratory, No. 101.

TABLE 1.—Records of the gag, *Mycteroperca microlepis*, in Virginia, 1960.

Location	Capture Method	Date	Fork Length, mm	Standard Length, mm
1. The Gulf, near Cape Charles	Oyster tray	8 July	61	49
2. Wachapreague, boat basin	Minnow trap	28 July	83	71
3. Cockle Point, Chincoteague Bay	Oyster tray	3 Aug.	94	79
4. Cockle Point, Chincoteague Bay	Oyster tray	3 Aug.	104	84
5. Cockle Point, Chincoteague Bay	Oyster tray	3 Aug.	110	90
6. Cockle Point, Chincoteague Bay	Oyster tray	3 Aug.	112	92
7. Swash Bay, Virginia Seaside	Oyster tray	9 Aug.	116	94
8. Killick Shoal, Chincoteague Bay	Crab pot	10 Aug.	150	125
9. Kiptopeke, ferry terminal pier	Hook & line	26 Aug.	148	119
10. Wachapreague, boat dock	Hook & line	5 Sep.	161	132
11. Fort Wool, mouth of James River	Hook & line	6 Oct.	186	156
12. Virginia Beach, steel pier	Hook & line	22 Aug.	None 2 specimens	—
13. Virginia Beach, steel pier	Hook & line	23 Aug.	None 3 specimens	—
14. Back River, mouth	Hook & line	Early Nov.	None	—
15. Gloucester Point, Virginia Fisheries Laboratory pier	Eel pot	18 Sept.	None	—

these fish were from the same year class. No annuli were seen on scales taken from the four largest specimens.

The smaller specimens were grouper-like in appearance with rounded caudal fins, and were generally dusky green with irridescent green, longitudinal wavy blotches. The median fins of Chincoteague Bay specimens were dusky green to black with lighter green blotches. The specimen from Kiptopeke closely fitted the description by Jordan and Evermann (1902:393–4). The dorsal was dark olive, with the tip of the soft dorsal blue black and narrowly edged with white. The caudal was mostly black with only a hint of blue, but with the trailing edge white. The anal was "deep indigo blue, olive at base, its edge white".

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H. D. HOESE, C. E. RICHARDS, and M. CASTAGNA

Virginia Fisheries Laboratory Station, Wachapreague, Virginia;
Virginia Fisheries Laboratory, Gloucester Point, Virginia; and
U. S. Bureau of Commercial Fisheries, Biological Laboratory, Oxford, Maryland (Franklin City, Virginia).

Book Reviews

Style Manual for Biological Journals. *By Conference of Biological Editors. Committee on Form and Style. American Institute of Biological Sciences, 2000 P Street, NW. Washington 6, D. C. 1960. Cloth, viii + 92. $3.00.*

Here at last is a technical writing guide for and by biologists. The cynic among the fraternity will declare immediately that the good writer doesn't need it, and the undisciplined writer won't use it, in preparing contributions for scientific journals. Whatever the response from the extremes of the normal curve of biological writers, there is a wide spectrum of people in between who will find sane and useful suggestions for improving their scientific presentation and insuring efficient communication.

The *Style Manual* fills a long-felt need. It treats in detail such topics as writing principles, preparation of copy, standard abbreviations, review of manuscripts, copy editing, proofs, and indexing. The section on preparing biological illustrations is especially fine. It is impossible to review adequately the wide range of topics or the richness of detail in the book. A testimony to its influence, practicality, and common sense is the list of 76 leading American biological science journals that have adopted it during its formative stages before letter-press publication. Drafts of the manual were read by about 100 editors and publishers, and all have contributed to its conciseness, readability, and attractive appearance.

Good scientific writing means a wider and more enlightened audience, and, parenthetically, money in the bank. The *Style Manual*, which incidentally reflects its own suggestions religiously, aggressively proclaims these by-words: accuracy, clarity, and parsimony. It has two primary objectives: (1) to tell the story of research briefly and efficiently; and (b) to reduce the costs of publishing. A scientific journal is charged about 6¢ a word. Good writing therefore produces an important bonus in financial saving to the journal and at the same time implies a professional competence in the contributor. Certainly, financial saving is not an end in itself. What is important is that the space and money saved can be used to publish work produced by the burgeoning population of new scientific workers in biology. The "Good examples of bad habits" should be required reading for all writers, although some of the corrected or concise versions of the examples could have been improved further.

In view of the overall excellence of the manual, it may be uncharitable to quibble over a few of the editorial choices. For example, the logic of the direct use of the personal pronouns "I" and "we," instead of "the writer" and "the author," is sound, since it is often impossible to tell when an author is referring to himself and when to some other person or persons. Similar recommendations have been made by Werner O. Nagel (1960. Make your technical writing useful. *Amer. Fish. Soc. and The Wildl. Soc. p. 25–6*) and Morris Fishbein (1950. Medical writing, the technic and the art. *2nd edit. The Blakiston Co. p. 53–4*), two references to which the *Style Manual* can be favorably compared. The emphasis, however, should have been to prevent confusion by the avoidance of the use of both forms. Authors who make extensive use of personal pronouns in scientific writing generally abuse their style, and are inclined to subjectivity and verbosity.

Recommended spellings and bibliographic citations may create some problems. The list of "spelling and usage of common words," which follows *Webster's New International Dictionary*, are excellent and will now be regarded by many biologists as the final step of arbitration in questionable cases. Some of the choices, nevertheless, are challenged: (a) if "homologue, *not* homolog," why "catalogue *or* catalog;" and (b) if "percentage," why not "percent" instead of "per cent?" Although the editors are to be commended for trying to make order out of chaos in reference citations, the multiplicity of examples (p. 62–5) tend to confuse rather than clarify the choice of proper form. If a new edition of the *Style Manual* is prepared, the most used types of references and recommended styles should be ranked in the beginning, and unusual cases should be relegated to the end or to small type.

The Editorial Staff of *Chesapeake Science* and the Editorial Committee of the Maryland Department of Research and Education have adopted the *Style Manual* for the preparation of all their scientific contributions. The "Instructions to Authors" given on the inside back cover of *Chesapeake Science* was planned initially with a manuscript copy of the *Style Manual*. A small number of differences exist in the style and recommendations of *Chesapeake Science* and the *Style Manual*. Contributors to our journal must give first priority to the style requirements of *Chesapeake Science*; all other uses should follow the *Style Manual*.

The *Style Manual* should reside on the reference shelf of all biologists, and should be available to wives and secretaries who type biological manuscripts. It will be an important tool for writers for many years, since it has anticipated the most important questions that a technical writer might pose. No other source-book in this field is as prodigious and useful. Although the bound volume is well worth the price, it is certainly too high to insure that most biologists will buy it. Perhaps a cheaper edition with stiff durable covers can be issued at a future date to encourage its use and distribution. One thing is sure, any writer who uses it will shorten the time lag between submission to and publication of his manuscripts in a journal.

His audience and editors will also share in the many benefits of this action.—ROMEO J. MANSUETI, *Chesapeake Biological Laboratory, Solomons, Maryland.*

Delaware Intrastate Water Resources Survey, 1959. *By The Delaware Basin Survey Coordinating Committee for the State of Delaware, J. Gordon Smith, Coordinator, Delaware Highway Department, P. O. Box 131, Dover, Del. 1960. Cloth, various pagination. Price unknown.*

Occasionally, and all too rarely, a region brings together most of the facts and ideas pertinent to a large community problem. Such an achievement collects the small parts, reveals the shape and nature of the whole problem, and may provide the perspective necessary for effective action. The State of Delaware undertook this rather massive task and has suceeded in incorporating in a single volume a remarkable quantity and variety of information about the "Diamond State." Recognition of the grave pressures which have been and will be brought to bear upon this small coastal state in the problem of future water supply was the stimulus. The dedicated efforts of a large number of people (at least 25 authors have apparently contributed directly to the book) made the quality and quantity of the contents possible. The product is a volume which has enduring value to the State of Delaware and merits wide interest among others who have water supply problems or resources similar to those of Delaware. The Eastern Shore counties of Maryland and Virginia will find this material to be especially pertinent.

On can learn about Delaware's topography, cultural resources, transportation, labor supply and the ideas of the Chamber of Commerce. Descriptions include the present water supplies of Delaware, the agencies concerned, water quality of the Delaware River, and activities of the State Game and Fish Commission. Beach areas, salt water barriers, factors affecting saline water conversion, forest resources, park needs and the legal aspects of various problems each receive attention.

Of special interest to readers of CHESAPEAKE SCIENCE is the portion dealing with "A Biological Evaluation of the Delaware River Estuary," which has also been issued as Publ. No. 3 of the Information Series of the University of Delaware Marine Laboratories (Price $1.25). Here Drs. Carl Shuster and Frank Daiber, with their students and associates, have produced a substantial contribution to estuarine science. There is an excellent summary of physical data on the Delaware estuary. This is followed by much new data and interesting discussion on the role of tide marshes, shore zone fishes, the ecology of estuarine invertebrates, and commercial and game fisheries of the Delaware Bay. There are many of the fresh and distinctive illustrations which characterize the new learning emerging from this laboratory. This report should be available in all laboratories where estuaries are of serious interest.

This volume has an unusual format. Sections are numbered and subdivided into sub-numbered divisions and tables. The format will appeal to some people but may present problems of optimal use to others. Its usefulness could have been constructively improved with the additions of regular pagination and a subject index. It is natural that the quality of the presentation varies from topic to topic and author to author. The present state of knowledge is equally variable among such a wide range of topics. The total result, however, is one of dedicated effort and personnel combined to provide a strong basis for intelligent planning and action.

The summary discussion section (Section XXIX of the Volume) presents estimates of future population, water use, potentials for reclamation, flood control and salinity conversion. Delaware may suffer in the future because of water shortages; however, this volume represents vigorous and constructive efforts to minimize that damage. The book's message in this respect also extends to other political members of the Delmarva Peninsula. The Delaware Intrawater Resources Survey may stimulate other states to complete similar valuable compendia.—L. EUGENE CRONIN, *Maryland Department of Research and Education, Annapolis and Solomons, Maryland.*

The Ecology of Algae. *By C. A. Tryon, Jr. and R. T. Hartman, Editors. The Pymatuning Symposia in Ecology. Pymatuning Laboratory of Field Biology, University of Pittsburgh, Pa. Special Publication Number 2, 1960. Cloth, v + 96. $2.00.*

The present emphases on the ecological approach and the impending implications of our world wide population problem support the need for immediate publication of results, data and speculations of ecological symposia. Since by all matter of media, algae are often purported to be the likely saviors of our human nutritional demands (raising beef necessitates a costly middle man in energy cycles), it is imperative that we try to explore this important area of algae and to share our knowledge. "The Ecology of Algae" does share the knowledge gained in the symposium and of its participants with its reader.

As is true for many publications of symposia, perhaps one of the greatest values of this one is the review of the recent literature and the references cited. Each writer appears to have carefully selected and made reference to other works pertinent to his field of exploration; particularly inclusive is that of Dr. Prescott. It is stated in the introduction that certain areas have necessarily been omitted, but in those included areas excellent coverage has been given.

Even though each chapter is written by different men, which is reflected in the styles of writing, the prime theme has been clearly kept in mind and there is no abrupt change from one area to another. Occasionally I was bothered with terminology but for the most part, technical words

and abbreviations were defined. It is well known that space is at a premium on a printed page, but I do believe that it would make easier reading if the reduction of type had been less.

The potential reader has only to scan the list of contributors (L. A. Whitford, J. L. Blum, G. W. Prescott, R. T. Hartman, A. F. Bartsch, J. H. Ryther, L. Provasoli, and I. J. Pinter) to realize that the topics vary from the effects of the environment on algae to the effects of algae on the environment, from oxidation processes to organic production and populations, and from the field to laboratory problems.

The Pymatuning Laboratory deserves praise for the publication of this symposium and while it will be of interest to most biologists, it will be particularly interesting and informative to the microbiologist, ecologist, and phycologist.—RUTH E. GRIFFITH, *Hood College, Frederick, Maryland.*

America's Best Bay, Surf, and Shoreline Fishing. *By Heinz Ulrich, Thomas Yoseloff, Inc. N. Y. 1960. 240 pages. Cloth, $5.00.*

The sport fishermen on the East and West Coasts of North America, at whom the volume is aimed, are certain to find this an interesting book. The title itself is misleading, considering that less than 50 pages are devoted to the "best bay, surf, and shoreline fishing." The remainder of the book consists of a short section called "fundamentals" which deals with the names, sizes, a brief description, range, catching technique, and edibility of various species of game fish. Following this, there is a longer section dealing with the actual angling features of some of the more popular species. From a local point of view, the Chesapeake area is considered in such brevity as to be virtually worthless as a guide to the fishing activities here.

Such biological facts as are mentioned are up to date and apparently accurate. Any inaccuracies which may be present are of omission rather than commission. It was noted that in considering the barracuda, its flesh was listed as edible but no mention was made of the occasional poisonous nature of the flesh of this fish (Halstead, 1959, Dangerous marine animals. *Cornell Maritime Press, p. 125*). Taken as a whole, the book should find wide acceptance among sport fishermen for its interesting material but its use as a guide to fishing areas and activities is questioned.—D. G. CARGO, *Chesapeake Biological Laboratory, Solomons, Maryland.*

Biological Problems in Water Pollution, Transactions of the 1959 Seminar. *Compiled by C. M. Tarzwell, Robert A. Taft Sanitary Engineering Center, U. S. Department of Health, Education and Welfare, U. S. Public Health Service, Bureau of State Services, Division of Water Supply and Pollution Control, Cincinnati, Ohio. Technical Report W60-3. Offset-printed. 1960. Paper, xv + 285. Price Unknown.*

This second report of the Taft Center Seminars has wider scope and greater depth than the first. Some aspects of pollution in need of immediate attention, especially disposal of radioactive materials and the effects of pesticides on aquatic life, have been treated in detail by experienced and renowned investigators in their respective disciplines.

Other sections covered by this volume are Environmental Requirements for Aquatic Life, Practical Application of Biological Findings in Pollution Abatement, Marine and Estuarine Pollution Problems (which sketches current problems on all major coastlines of the United States), Oil Refinery Waste Problems, and in a section entitled "Informal Group Discussions," brief resumés of specialized discussions during the seminar are reported.

This large volume will be a valuable reference for those concerned with pollution problems. Two criticisms are due this work: (1) it has an abundance of "philosophical" presentations, primarily by administrators (these do, however, make one glad one did not have to sit through the oral presentations), and (2) the relative inaccessibility of the valuable information in this book. This type of report has less general distribution than journals concerned with this field that might have carried the seminar report, and a corollary which follows this is its accessibility in libraries. Ten years hence, will this volume be listed in the library catalogues under Tarzwell, as compiler, under U. S. Department of Health, Education, and Welfare, or H. E. W., under U. S. Public Health Service, or USPHS, under Robert A. Taft Sanitary Engineering Center or Taft Sanitary Engineering Center?—DONALD LEAR, *Chesapeake Biological Laboratory, Solomons, Maryland.*

Water and Agriculture. *Edited by Roy D. Hockensmith. American Association for the Advancement of Science, 1515 Massachusetts Avenue, NW, Washington 5, D.C. 1960. Cloth, 206 pages. $5.00.*

Presented in this volume are 16 authoritative papers dealing with water as it relates to agricultural uses in the United States, grouped into four sections: water for the future, water sources, water planning and use, and water control. All were presented in a symposium at the 1958 meeting of the AAAS.

Though the title and introduction stress agricultural water uses and problems, most of the papers are broad presentations which will be of considerable interest to power, navigation, recreation, pollution and industrial water users. A single reading provides a concise and stimulating review of current water problems and their implications for the future. The editor has overcome many of the inherent problems attending publishing a symposium, and the whole work is arranged in a logical, smooth reading sequence.

Under the section on water for the future, the authors discuss future planning and development of water resources, legal aspects of water use, the Soil Conservation Service small watershed pro-

gram, water management, and ground-water supplies. Clarence A. Davis, Washintgon, D.C. attorney, in his paper on the legal aspects of water use, gives a fresh review of a complex national problem and leaves a definite impression that far-reaching changes are inevitable in water use law. R. L. Nace of the Geological Survey, under the ground-water supply discussion, uses an example close to the Chesapeake watershed. The proposed deepening of a section of the Delaware River would result in a recharge of inland aquifers, through groundwater channels, from the river. Here would occur the interesting effect of river water quality on ground water supplies, the reverse of the usual situation. Needless to say, this aspect will concern all coastal river watersheds where navigation is important.

In the Water Sources section, William C. Ackermann, Illinois State Water Survey Division, offers surprising evidence of man's increased ability to modify the old familiar hydrologic cycle. Others discuss new findings and implications of weather modification, and the use of climatic and precipitation data in farm management.

Soil conservation practices, forest management, stream management and reclamation projects are discussed under the water planning and use section. Here the authors present candid views of both sides of controversial issues such as big dams vs. small dams, and who should pay for the benefits furnished by water control structures.

The water control section is weak in that it lacks the broad, frank approach of the papers in the other sections. The paper on agricultural drainage omits any reference to two highly controversial effects of this practice: loss of waterfowl habitat, and increasing farm acreage in a food surplus economy. The paper on aquatic and bank vegetation and phreatophyte control is slightly alarmist in tone, and the very interesting subject of controlling evaporation from reservoir surfaces is one which is in abstract form. The paper by C. B. Tanner of the University of Wisconsin on the energy balance approach to evapotranspiration from crops is one well put last, being by far more technical than those of his colleagues on the symposium. The reader will most likely stop here and return to this paper at a later reading.

The only true disappointment of the book is finding three papers in abstract form, leaving a thirst for the original paper and references.

This book fills a dual role as both a basic primer on water use problems and a handy reference in a personal natural resources library.—JOSEPH S. LARSON, *Maryland Department of Research and Education, Annapolis, Maryland.*

Wild Animals of North America. *By A. Remington Kellogg and Merle Severy, editors. National Geographic Books Service, Washington, D. C. 1960. Cloth, 400 pp. $7.75.*

This is one of the most sumptuous and colorful books ever produced on the mammals of our continent. Published in a first edition of 200,000 copies, it is the latest volume in the well-known Natural Science Library series of the National Geographic Society. Anyone familiar with the recent issues of their magazine and the Society's first mammal book published over 40 years ago will recognize many of the fine colored illustrations. Of the 409 pictures, over half are new, and 258 are in color.

The "Wild Animals of North America" is foremost a picture book, and secondarily a reference book. This is not to say that the writing takes a back seat; on the contrary, the text, through excellent editing, is brief, informative, and many times scintillating and humorous. The book has resulted from the combined effort of many talented writers, artists, photographers, and editors. Many chapters have appeared from time to time in the magazine, but all have been rewritten, augmented, and edited for the book. Descriptions for most species are purposely short and concise, contrary to the long detailed accounts in the Society's first mammal book by E. W. Nelson, in order to provide space for the illustrations. The whole book is slanted to amateur naturalists, hunters, conservationists and children. The sophisticated conservationist and biologist cannot use it as a technical manual, since there are many other superior books on mammals available, but they will undoubtedly turn to the illustrations for serious reasons.

The book treats these major groups: animals in fur, the hoofed mammals, the meat eaters, gnawing mammals, survivors of ancient orders, and ocean dwellers. Dr. Kellogg, a distinguished mammalogist who has worked extensively on the fossil mammals of the Chesapeake Bay, prepared the general introduction on mammals and the chapter on whales, in addition to serving as a general technical editor. Other well-known contributors and their topics include: Victor H. Cahalane (deer and cat family), Robert M. McClung (mustelids and bison), Stanley P. Young (canines), Wayne Barrett (bears), Goode P. Davis (rodents), and Donald R. Griffin (bats). An enormous amount of detail on the biology, economic and recreational value, effects of conservation measures, and ecological requirements are given in the short, bright accounts of the mammals.

This popular book, of necessity, functions as a sampler of the mammal fauna of North America. There are approximately 400 species, excluding subspecific forms, found north of the Mexican boundary. Of these, the book describes 138 of the most striking and important species. In the greater Chesapeake Bay drainage system of Maryland and Virginia, there are approximately 100 species of terrestrial and aquatic mammals. Only about 60 are described and illustrated in this book. Such treatment also probably applies to other areas. Those that are left out include the small, rare, uncommonly observed, or aquatic mammals. It is too bad that these less glamorous forms do not provide the justification for inclusion rather than exclusion. Certainly the existence of secretive, shy and rare mammals should be pointed out to stimu-

iate further study. Most readers won't miss the mammals that are left out, however, because of the rich treatment of those that are included.

The paintings of mammals in natural settings leave one breathless. The difficulty in photographing many of the secretive, nocturnal, or less known families, especially the shrews, rodents, bats, weasels, and aquatic mammals, has resulted in the great reliance upon the talents of wildlife artists. Many of Louis Agassiz Fuertes' fine paintings from the Society's first mammal books have been reprinted. Mammal paintings by Carl Rungius serve to establish him as one of our greatest wildlife artists. Some of the other fine color reproductions are by Charles R. Knight, Andre Durenceau, and Else Bostlemann, but the bulk are by the National Geographic Society's staff wildlife artist, Walter A. Weber. He displays a wide versatility, a fine style, and immense talents. Most of his paintings represent exquisite portrayals equal to the best work of other top artists. By and large, his work provides the theme around which the whole book seems to revolve.

The Society has apparently spared no expense in assembling the magnificent series of action color and black-and-white photographs. These capture characteristic expressions and poses in wild mammals that are rarely recorded by painters. The photographers are legion, including those from the Walt Disney Studios, but some of the finest shots were taken by Wendell Chapmann, Frank and John Craighead, Tom McHugh, Charles E. Mohr, Harold E. Edgerton, Ernest P. Walker, and Lloyd Beebe. The picture editor has shown a remarkable facility in balancing these photographs so that they effectively complement the paintings.

Classically, wild mammals and civilization have been incompatible. If we are to stem the tide of extirpation and decline for many important and spectacular forms, the serious aspects of wildlife management and conservation, especially the details of specialized adaptation and ecology, population dynamics, and exploitation by man, must be stressed and explained frankly to the public in popular, widely used books such as this. This book is a great success in this mission.

The "Wild Animals of North America" can be scored as a National Geographic Society triumph in spite of minor criticisms of content. Considering the quantity of colored illustrations, the handsome appearance of the book, and the quality of writing and pictures, the book is a bargain. It is recommended without hesitation for all school libraries, outdoorsmen, and families with children enamored by animals.—ROMEO J. MANSUETI, *Chesapeake Biological Laboratory, Solomons, Maryland.*

Freshwater Fishes in Mississippi. *By Fannye A. Cook, Mississippi Game and Fish Commission, Jackson, Miss. 1959. Soft-bound, 239 pages, 2 maps. $3.00.*

Up-to-date and reliable books on the freshwater fishes of southern waters are scarce. The "Freshwater fishes in Mississippi" is one of these rare productions. Miss Cook, for many years an outstanding vertebrate zoologist in Mississippi, and now retired Museum Curator of the Commission, worked on the fishes of her state for over two decades. She began her work where Samuel F. Hildebrand left off in 1933 and 1936, and regarded "Dr. Hildebrand's work an inspiration and a challenge." In passing, it may be noted that the versatile Hildebrand began his work sometime after publication in 1928 of his "Fishes of Chesapeake Bay." In one sense the book is a fitting memorial to his pioneering efforts in the state; his influence and copious records are found throughout the book. In another sense, it is a fine tribute to the author who worked almost alone in a little-known region.

The freshwater fishes, especially cyprinids or minnows, from many watersheds of southern United States are poorly known. As a result, Miss Cook relied on assistance from the many specialists who work with the excellent fish collections in the natural history museums of Michigan, Washington and elsewhere. She remarked about her objectives, "The work has been done in the hope that the book may serve as a basis for further study, as a reference in research, and as a handy key for identification of species found here." She has succeeded admirably. Estuarine biologists will find she has enlisted the aid of Dr. Gordon Gunter in compiling a list of marine species which sometimes enter fresh water, although a reciprocal list of freshwater forms that enter brackish or salt water, which is lacking, would have made an interesting comparison.

This book contains the essential ingredients of a handy and helpful handbook: neat and clear illustrations (all original and unfortunately too few); detailed diagnostic keys down to species; and, authoritative accounts of the habits and distribution of each species. A glossary, a detailed list of the old and new references to the ichthyofauna of the South, and an index round out its major features. A rich brocade of information is provided in the introduction on the history of local ichthyological investigation, watershed and stream systems, and some basic information on the characteristics of fishes. It is unfortunate that distribution maps could not have been included, although it is recognized that the cost would have been excessive in this well-produced, letter-press volume. The text type is small, hence the book contains a vast amount of information for its length.

Although Mississippi may be far removed from the Chesapeake drainage and other eastern states, the book contains interesting new information about some of the local species also found in these states. For example, 39 out of 157 fishes found in Mississippi also occur in Maryland fresh waters. A more important value of the book is its potential in stimulating workers in other southern states to produce similar handbooks that will conform to the high standards it has set. There seems little doubt that the "Freshwater fishes in Mississippi" will prove to be an important reference manual

for many years to come. Everyone having a serious interest in freshwater fishes should own it. Miss Cook and the Mississippi Game and Fish Commission must be commended for bringing it about, and perhaps for giving provincial ichthyology below the Mason-Dixon line a shot in the arm.—ROMEO J. MANSUETI, *Chesapeake Biological Laboratory, Solomons, Maryland.*

Biological and Chemical Control of Plant and Animal Pests. *Edited by L. P. Reitz. American Association for the Advancement of Science, 1515 Massachusetts Avenue, NW, Washington 5, D. C. 1960. Cloth, 285 pages. $5.75 regular, $5.00 prepaid to AAAS Members.*

This volume is a collection of the 19 papers presented at the Symposium on Agriculture held at the Indianapolis meeting of the AAAS, December 28–30, 1957. The editor has systematically arranged the papers under three topics: the public's stake in pest control; the recent advances in chemical control; and the biological control of pests.

Part I is primarily concerned with alerting the general public to economical losses caused by pests in an effort to obtain public support for control programs. It is within this section that the main theme for the symposium emerges, "Eradicate [by any means], if possible." This has been somewhat successfully achieved in the past by quarantines and chemical controls, and recently by the innovation of biological controls.

Part II deals with recently developed chemicals, their recommended dosages, their effectiveness as control agents, and in many cases the mechanisms by which they effect their toxicity. The most sought after chemicals at present are those that become systemic in plants and animals and prevent infestations. Although present day pesticides number in the thousands and the majority of these have been developed since World War II, chemical control of pests is not by any means a recent innovation.

Part III deals with the use of parasites, predators, and pathogens in the control of pests and the development of disease resistant species of animals and plants by selective breeding and hybridization. Of major significance in the area of biological control was the complete eradication of the screwworm fly *Callitroga hominivorax* in Florida and other southeastern states by releasing among the wild population male flies that had been made sexually sterile by exposure to gamma rays.

By and large, *Biological and Chemical Control of Plant and Animal Pests* is well organized and easily readable, presenting an up-to-date source of information and numerous references of invaluable importance to agriculturists, silviculturists, entomologists, parasitologists and toxicologists.

The comprehensive title is, however, misleading since the role of chemicals in the control of aquatic plant and animal pests has been completely ignored. For example, in recent years the Aquatic Weed Control Program of the Patuxent Wildlife Research Center has found herbicides effective for the control of water hyacinth, alligator weed and water chestnut. Specifically, 2,4-D has been successfully used by the states of Maryland and New York in combating water chestnut. Added to this list in the last two years is the European water milfoil *Myriophyllum spicatum* which has taken over in many of the low salinity tributaries of Chesapeake Bay and has destroyed many beds of aquatic plants utilized as food for waterfowl.

The investigations of the National Institutes of Health, The Walter Reed Army Institute of Research and the Naval Medical Research Institute in the use of chemicals as molluscacides to control various species of Planorbidae that serve as intermediate hosts for the blood flukes responsible for schistomiasis have been omitted. Also left out is the work of V. C. Applegate and his co-workers of the U. S. Fish and Wildlife Service who have tested 4,346 chemicals for their toxicity to larval sea lamprey eels and fishes in their campaign to rid the Great Lakes of this noxious parasite.

Equally neglected were the investigations of V. L. Loosanoff and co-workers of the U. S. Bureau of Commercial Fisheries in screening the effects of several thousand organic compounds and the development of methods for their use in the control of starfish *Asterias forbesi*, oyster drills *Eupleura caudata* and *Urosalpinx cinereus*, boring sponges *Cliona celata*, green crabs *Carcinides maenas* and other pests that prey on oysters and clams.

This reviewer is of the opinion that any future symposia on Chemical and Biological Control of Plant and Animal Pests should include investigators from the above cited organiaztions. Since more than 70 percent of the earth's surface is water, the aquatic environment cannot be ignored. —L. W. SHEARER, *Chesapeake Biological Laboratory, Solomons, Maryland.*

Instructions to Authors

Scope—CHESAPEAKE SCIENCE will consider all original technical manuscripts based on research and management studies on the natural resources of the greater Chesapeake region. Suggested subjects include fisheries, wildlife, forestry, plant life, watersheds, hydrographic conditions and related natural resource phenomena pertaining to the drainage systems and adjacent land masses of the Chesapeake and contiguous areas. Research conducted elsewhere, but which is applicable to the Chesapeake region, will be acceptable. Review papers must be of a critical nature or suggest new and important generalizations. All authors are strongly advised to have their colleagues or specialists review their manuscripts before submitting them for consideration.

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Cowles, R. P. 1930. A biological study of the offshore waters of Chesapeake Bay. *Bull. U. S. Bur. Fish. 46(1091): 277–381.*

Brooks, W. K. 1905. The oyster: a popular summary of a scientific study. *Johns Hopkins Univ. Press, Balto. xvi + 225.*

Illustrations—All illustrations, each with a separate, consecutively numbered typewritten caption, will be designated as figures; plate designations will be avoided. Each should be identified by the number, author, and abbreviated title on the back. Each will be reproduced either as one column (2⅝″ width) or full page (5⅛″ width), in the latter case either vertically or horizontally. In planning large illustrations keep in mind the proportions of the printed page (5⅛″ x 8⅛″) within which all details and legends should be included. Line drawings, maps, charts, and graphs are reproduced as line engravings, and should be at least twice as large as they appear when reproduced. They should be drawn in india ink on a good quality, non-absorbent paper or tracing paper. All lettering by hand or from an Executive IBM or similar typewriter must be neat and sufficiently large to be at least *one mm high on final reduction*. Blue-line graph paper and light blue pencil guide lines are acceptable for the preparation of line cuts. Half-tone figures, such as photographs, wash-drawings, and paintings, should be submitted in flat condition in the original and also as sharp and clear glossy photographic prints with good contrast. The latter should be 5″ x 7″ or 8″ x 10″.

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